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BRONCHIAL CARCINOMA

A ROENTGENOLOGIC-PATHOLOGICAL STUDY*

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CANCER of the bronchus does not show directly in the roentgenograms until it is in a very advanced stage. Nevertheless, the fact that it causes more or less pronounced bronchial stenosis makes possible its rather early diagnosis by roentgen examination.

We all know that incomplete blocking of the bronchial tubes causes emphysema, complete blocking, atelectasis; and that

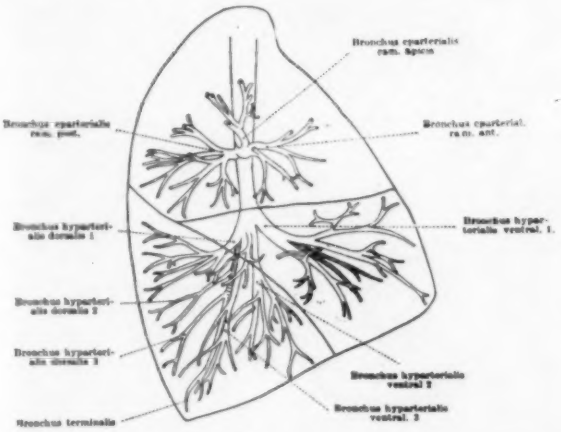

FIG. 1. The branches of the right bronchus as seen from the right. (By Hasse.)

emphysema and atelectasis cause respectively expansion and collapse of the thorax, depression and elevation of the diaphragm, pressure and pull on the mediastinum. The respiratory pendulum rhythm of the heart and mediastinum, which is a characteristic symptom of bronchial stenosis, was first described by Holzknecht.

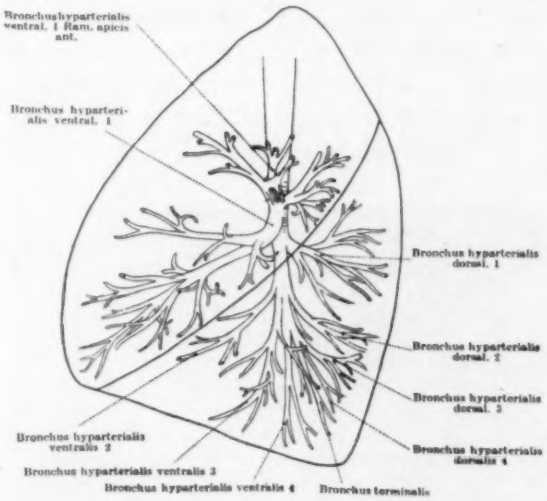
Bronchushyparterialis ventral. 1 Ram. apicis ant.
Bronchus hyparterialis ventral. 1
Bronchus hyparterialis dorsal. 1
Bronchus hyparterialis dorsal. 2
Bronchus hyparterialis dorsal. 3
Bronchus hyparterialis dorsalis 4
Bronchus hyparterialis ventralis 2
Bronchus hyparterialis ventralis 3
Bronchus hyparterialis ventralis 4
Bronchus terminalis

FIG. 2. The branches of the left bronchus as seen from the left. (By Hasse.)

To be able to make an early roentgen diagnosis of bronchial cancer one must be thoroughly acquainted with the anatomy of the bronchi and with the various stages of bronchostenosis, specially the slighter degrees.

The right main bronchus divides into the eparterial bronchus, and the hyparterial bronchus. The eparterial bronchus divides into one apical, one ventral and

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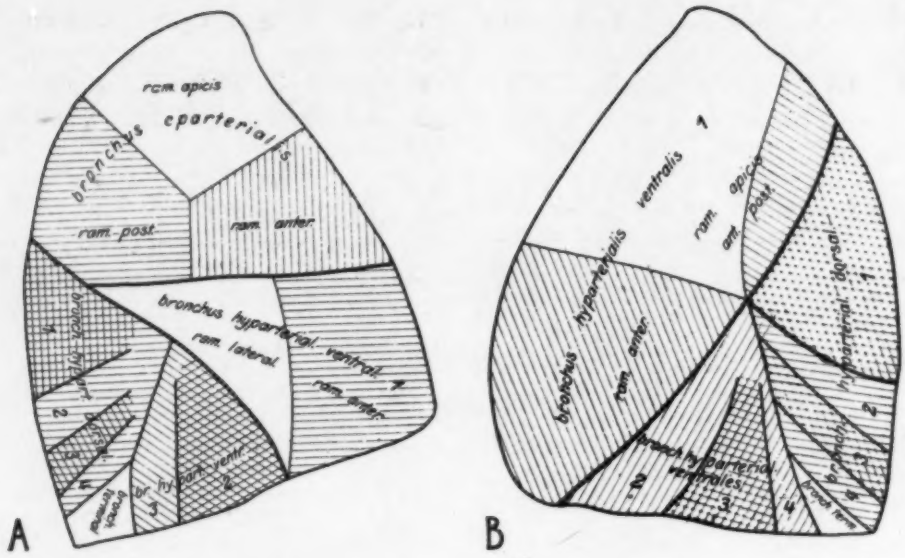

Fig. 3, *A* and *B*. The areas of the lung corresponding to the extent of the bronchial branches. Lateral view. (By Hasse.)

one dorsal branch. The hyparterial bronchus divides into four pair branches, every pair into one ventral and one dorsal branch. The eparterial bronchus runs to the upper lobe, the first ventral branch from the hyparterial bronchus runs to the middle lobe, the other branches run to the lower lobe.

The left main bronchus divides into four pair branches, every pair into one ventral

Fig. 4. Lateral view of the right lung on roentgen examination with the areas corresponding to the extent of the bronchial branches of the right lung.

Fig. 5. Lateral view of the left lung on roentgen examination with the areas corresponding to the extent of the bronchial branches of the left lung.

and one dorsal branch. The first ventral branch runs to the upper lobe, the other to the lower lobe. The first ventral branch divides into one upper and one lower branch. The upper branch divides into one apical, one ventral and one dorsal branch.

In order to gain a knowledge of the areas of the lung in the roentgenogram corresponding to the extent of the bronchial branches, I have made a study of about 200 examinations where bronchography was carried out. The result of this investigation is seen in Figures 4 and 5. It is necessary to have lateral roentgenograms of the lung to study the areas corresponding to the extent of the bronchial branches.

As I have pointed out in earlier papers, the changes primarily resulting from bronchostenosis remain strictly localized to an area corresponding to the extent of the stenosed bronchus in the lung. They thus become wedge shaped, the point of which is toward the hilum, while the base is directed either backwards or forwards, because the bronchi give off lateral branches which turn either in dorsal or in ventral direction.

From the roentgenologic point of view, bronchostenoses may be grouped into three stages, according to the degree of the constriction (Table 1). If the stenosis is slight, it produces a slight opacity, due to diminished air content and hyperemia. Though the passage is not as good as in normal bronchi, the slight constriction still permits the air to pass in breathing; but during inspiration the part of the lung peripheral to the stenosis will not become as well filled as the rest, and its air content will therefore be less. The resulting intra-alveolar pressure affects also the capillaries, so that these become filled with blood to an increased extent, intensifying the opacity.

A more pronounced stenosis causes valve action. As the bronchial tubes expand during inspiration and become narrower during expiration, the air passes the stenosis in greater volume during the inflow than during the outflow. As a result, air is retained in the part of the lung peripheral to the stenosis; and this causes emphysema, more pronounced during expiration than during inspiration. This emphysema causes increase of the intra-alveolar pressure, whereby the capillaries become compressed, and the portion of the lung peripheral to the stenosis becomes anemic. In the roentgenologic picture a wedge-shaped rarefaction

Table I

Stage	I	II	III
Appearance	Slight density caused by diminished air content and hyperemia	Rarefaction caused by emphysema and anemia	Massive density caused by atelectasis and hyperemia
Localization	To the area corresponding to the extent of the stenosed bronchus		
Shape	Wedge shaped	Expanded wedge with convex limits	Retracted wedge with concave limits
The surrounding lung tissue	Normal	Atelectatic	Emphysematous
Diaphragm	Diminished movements	Pushed down	Drawn up
Cor and mediastinum	Drawn to the involved side	Pushed from the involved side	Drawn to the involved side
Thorax	Depressed	Expanded	Depressed

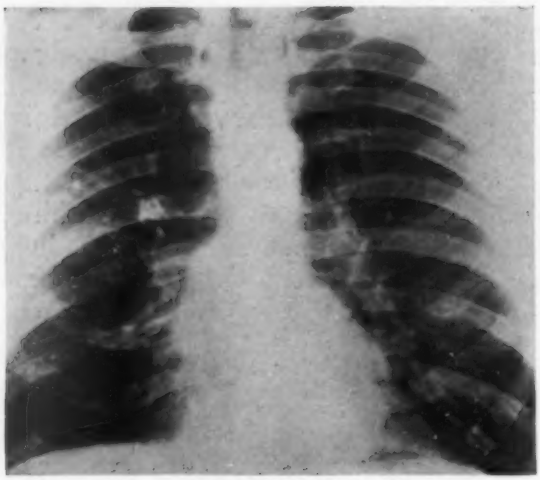

Fig. 6. Early case of cancer of the second dorsal bronchus from the right hyparterial bronchus. There is an emphysema in the area corresponding to the extent of this bronchus.

corresponds to this part. The limits of this rarefaction are convex because the retention of air causes the involved lung area to expand. At the same time, this expansion causes compression of the adjacent lung tissue, which thus becomes atelectatic and the rarefaction thus becomes surrounded by a dense marginal zone. This dense marginal zone can be more pronounced in one direction than in another, so that a band-shaped density can appear in the roentgenogram about the rarefaction. If the expansion is very great, the heart and mediastinum are pushed over toward the healthy side. Between Stage I and Stage II there is a transition stage with inspiratory density and expiratory rarefaction.

If the stenosis has caused complete occlusion of the bronchus, the result is a massive opacity, localized to the area peripheral to the constriction. This opacity is due to atelectasis and hyperemia. The atelectasis is the result of the air in the shut-off portion of the lung becoming resorbed, whereby the alveoli collapse, and the lung comes to occupy a smaller space than under normal conditions. In consequence of this, the wedge-shaped opacity appears with concave limits. Also the intra-alveolar pressure is reduced, and as a result the capillaries become overfilled with blood. If the atelectasis is pronounced and fairly extensive, the heart and mediastinum are drawn over toward the affected side.

If the roentgen examination has shown the existence of a bronchostenosis which takes a chronic course, bronchial cancer should always be suspected, and bronchography be done. In the bronchograms, the cancerous infiltration of the bronchus will show as an unbroken and continuous defect with rigid and ragged contours which may

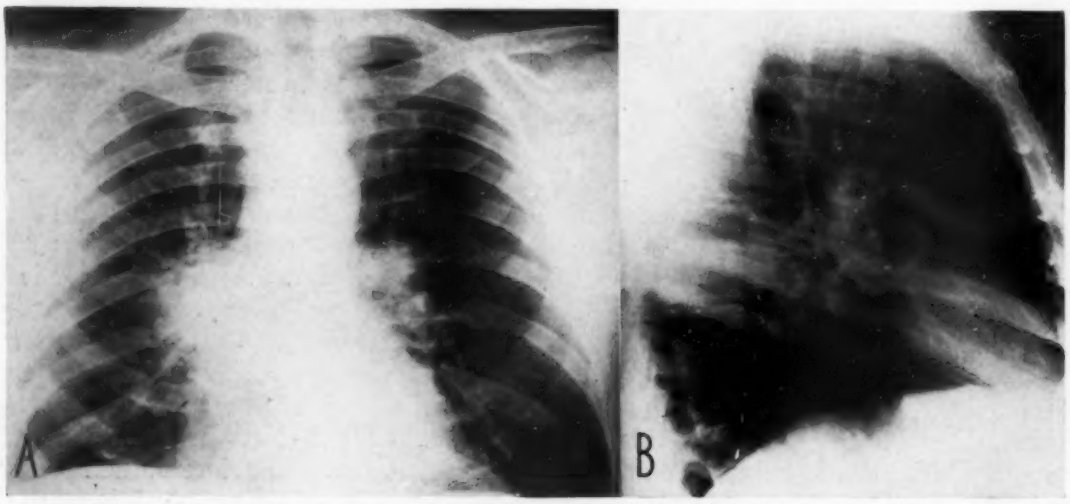

Fig. 7, *A* and *B*. The same case two months later. There is now an atelectasis in the area corresponding to the extent of the same bronchus.

infiltrate only one bronchus or several lateral branches from the same bronchus.

In the years 1930–1936, I have had occasion to diagnose by roentgen examination 46 cases of bronchial carcinoma. All were patho-anatomically verified, and were observed for a shorter or longer period.

Histologic examination showed in the different cases either slightly differentiated cylindrocellular cancer or slightly differentiated plate-epithelial cancer, or else entirely undifferentiated cancer. These different patho-anatomical characters were fairly equally represented.

Cases of bronchial cancer seem to be relatively more frequent in Sweden in recent years than formerly. Thus, in my material cancer of the stomach occurs 6.5 times as often as cancer of the bronchus; while in Nyström's statistics from Sweden for 1911–1912 cancer of the stomach occurred 74.5 times as often as cancer of the lung.

In my material, the age of the patients is from thirty-eight to seventy-five years. Not less than half of them were under fifty years. The average age for bronchial carcinoma thus seems to be somewhat less than the average for cancer as a whole, a fact which has been noted also by other authors, as Lenk and others. From the older statistics it would appear, however, that, on the whole, the age for cancer of the lung corresponds with the average age for cancer in general.

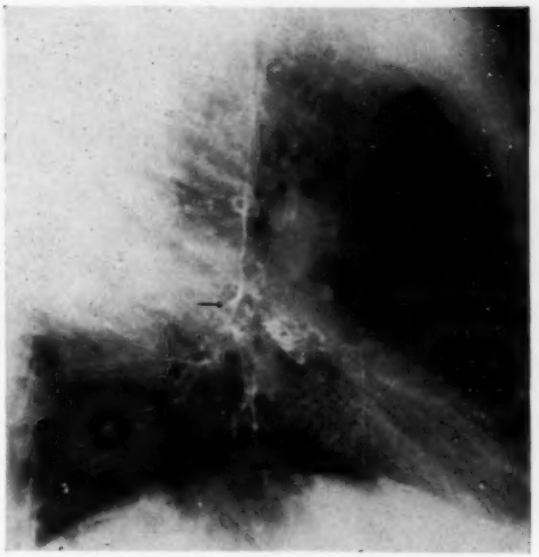

Fig. 8. The same case after bronchography. The second dorsal branch from the right hyparterial bronchus is occluded, with ragged contours.

According to most of the statistics, bronchial cancer occurs with much greater frequency in men than in women. In my

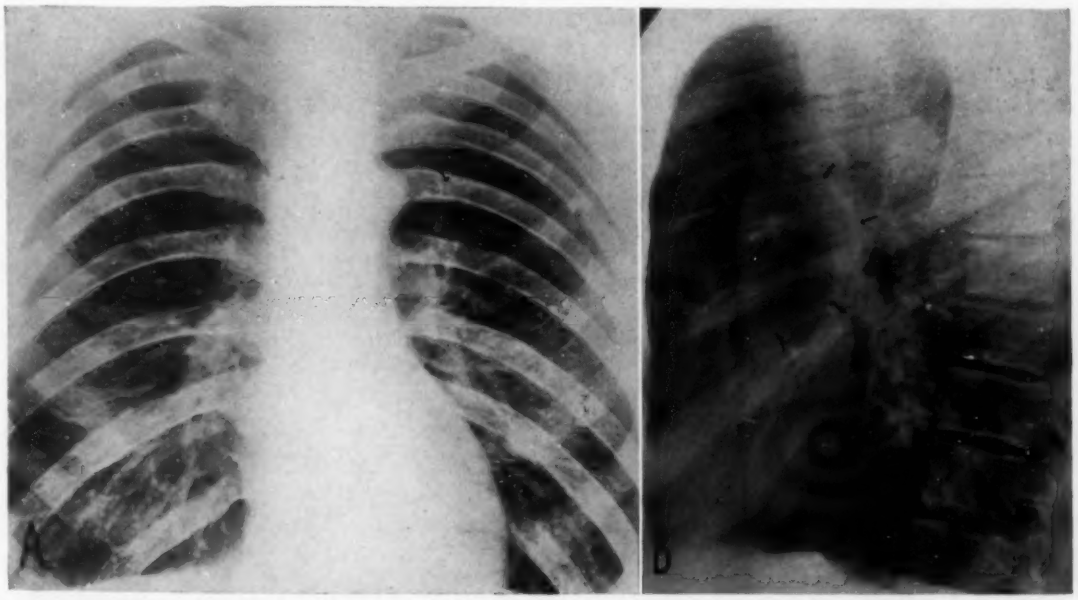

Fig. 9, *A* and *B*. An early case of bronchial cancer. A slight emphysema in the left upper lobe.

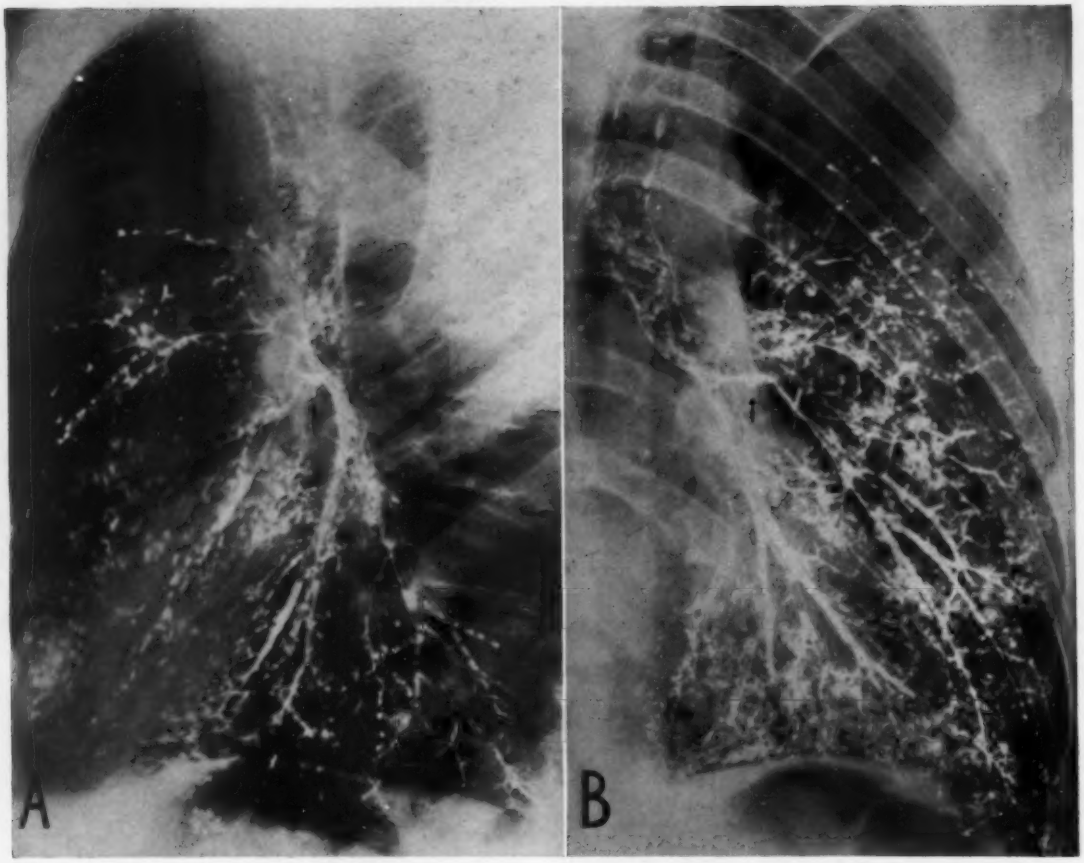

Fig. 10, *A* and *B*. The same case as Figure 9 after bronchography. In the first ventral bronchus there is an irregular contour with a length of about 1 cm. Verified by bronchoscopy.

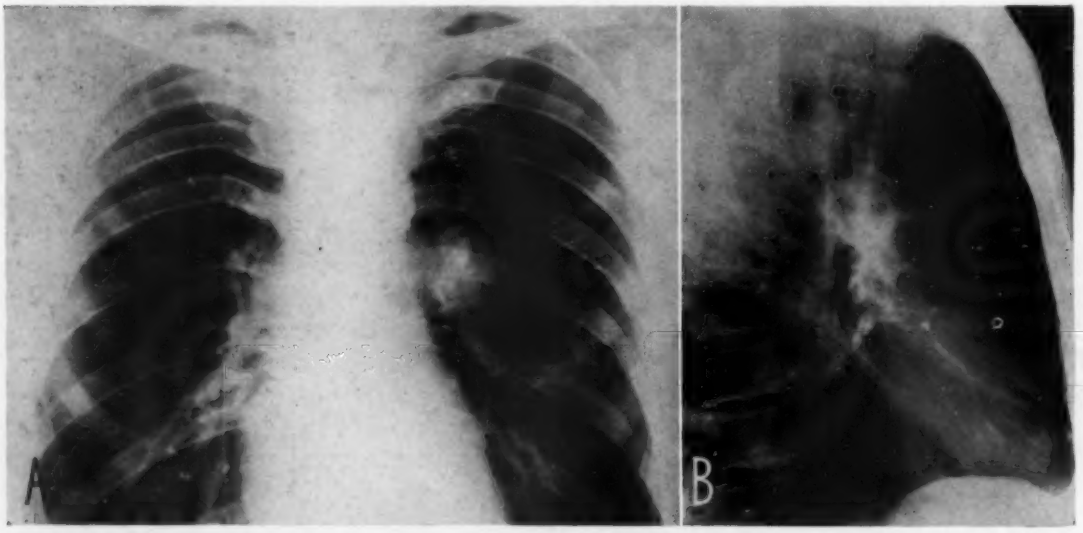

Fig. 11, *A* and *B*. Case of cancer of the upper frontal branch of the first ventral branch of the left main bronchus. There is an emphysema in the area corresponding to the extent of this bronchus. A large gland in hilum.

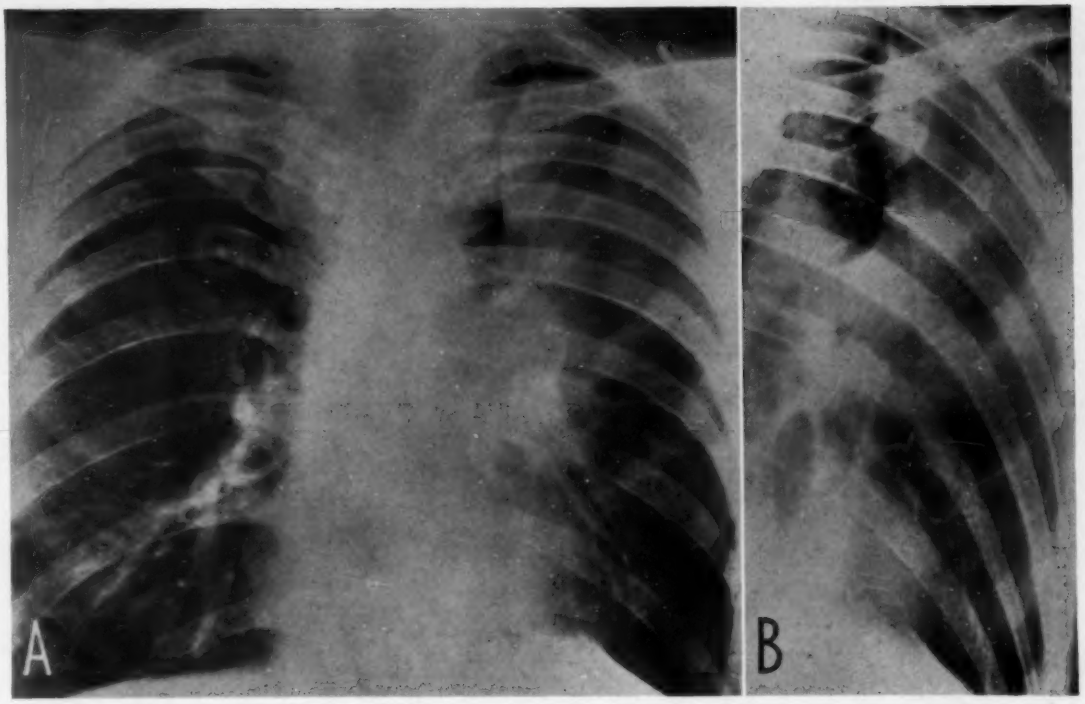

Fig. 12, *A* and *B*. The same case as Figure 11 three months later. Spontaneous pneumothorax and atelectasis of the upper part of the upper lobe.

material the ratio is 5 to 1. According to most authors (Kaufmann, Lenk, *et al.*), the localization is preponderantly to the right lung, and in most cases to the superior lobe. They also state that the primary tumor usually has its seat in one of the two main bronchi, and then as a rule immediately below the bifurcation. Wolf,

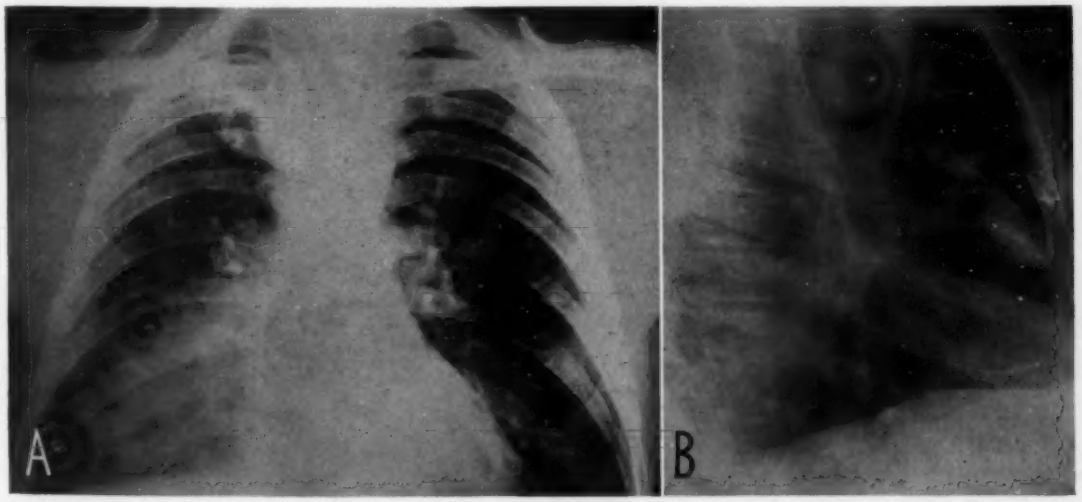

Fig. 13, *A* and *B*. Case of cancer of the right hyparterial bronchus with atelectasis of the dorsal part of the lower lobe corresponding to the extent of the dorsal branches of the hyparterial bronchus and emphysema of the middle lobe and the frontal part of the lower lobe corresponding to the extent of the two first ventral branches of the right hyparterial bronchus.

Fig. 14. The same case as Figure 13 after bronchography. Cancer involving the right hyparterial bronchus with occlusion of the dorsal branches corresponding to the atelectasis and a moderate stenosis of the two first ventral branches corresponding to the emphysema.

Kikuth, and others, say that this is so in not less than one-third of cases. The cases that do not arise from one of the main bronchi are supposed to arise from one of the larger branches, less frequently from the smaller ones.

From a patho-anatomical point of view, bronchial cancers are divided into different types, according to the site from which they arise, and their extension in the lung. In many cases the cancer is confined to the bronchial mucosa alone, in which case it produces circumscribed thickenings, polypous formations or circular infiltrations in the bronchial wall, all of which result in more or less pronounced stenosis of the affected bronchus. In some cases the cancer spreads peripherally farther out into the bronchi and reaches the alveoli, though without actually infiltrating the lung. In other cases its growth is more infiltrative. It then breaks through the wall of the bronchus and grows into the surrounding lung parenchyma, forming more or less circumscribed tumors close to the hilum. Again, in other cases, the infiltration is confined to the immediate surroundings of the bronchi, whence it then spreads along the latter in the form of thick, string-like infiltrations. Finally, the cancer may grow from its starting point into the lymph vessels, which become infiltrated; and here also string-like infiltrations are formed,

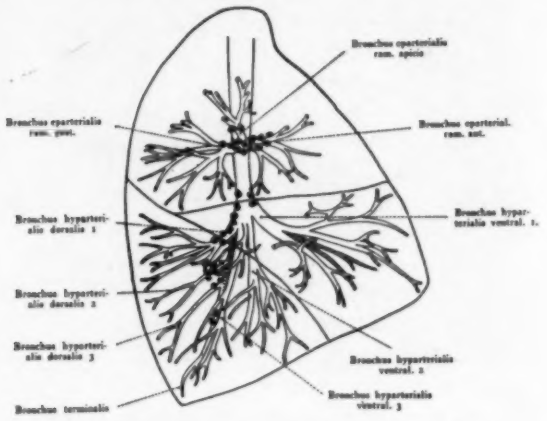

Fig. 15. The localization of the cases of cancer of the right lung by the first examination.

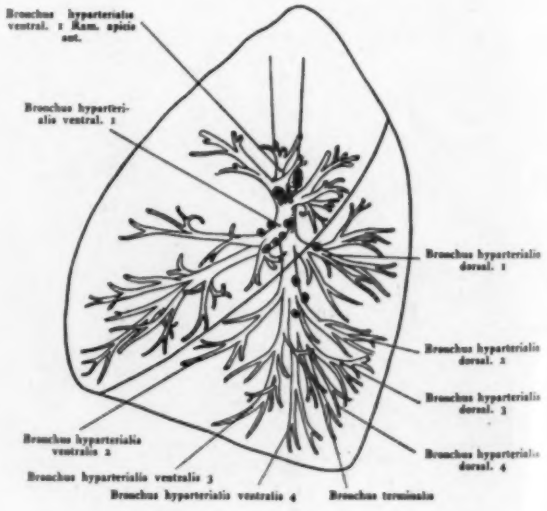

Fig. 16. The localization of the cases of cancer of the left lung by the first examination.

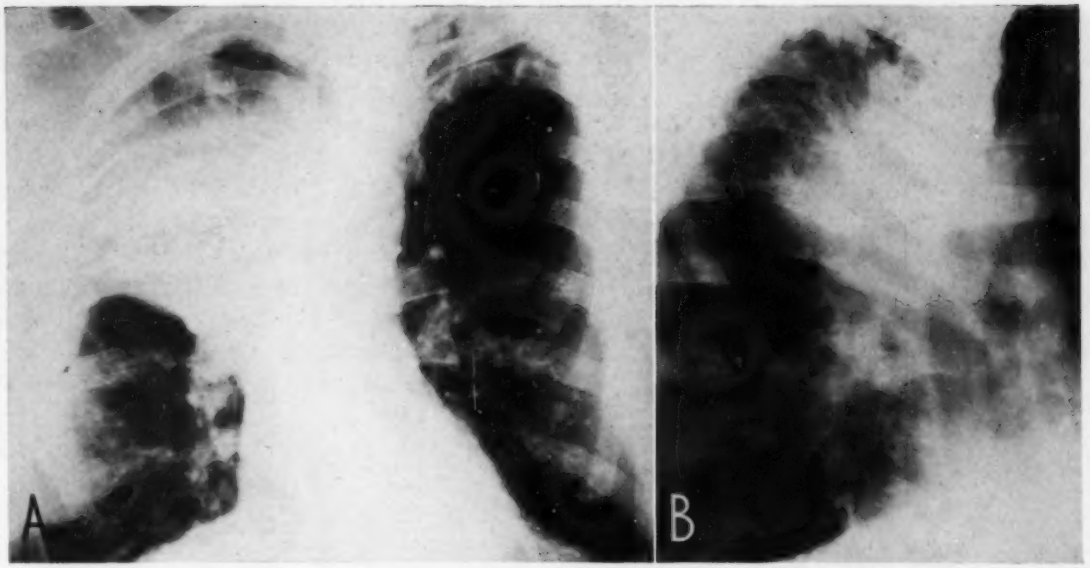

Fig. 17, *A* and *B*. A case of cancer of the ventral branch from the eparterial bronchus with atelectasis in the area corresponding to the extent of this bronchus.

radiating out into the lung. Thus we get the picture of so-called carcinomatous lymphangitis. In rare instances, the cancer may arise from one of the finer subdivisions of the bronchi. In this case it usually grows as a benign tumor, expansively, in all directions, and forms a well delimited tumor in the periphery of the lung. These conceptions of the localization and development of bronchial cancers in the lung are based chiefly on studies of post-mortem material. But that material usually shows only the final stage of the cancer, and in most cases does not enable one to come to any definite conclusion with regard to the primary localization.

My material, on the other hand, consists of cases which have been under observation for a considerable time. In several instances the observation time has been as much as three years, and the great majority were followed more than two years. The fact

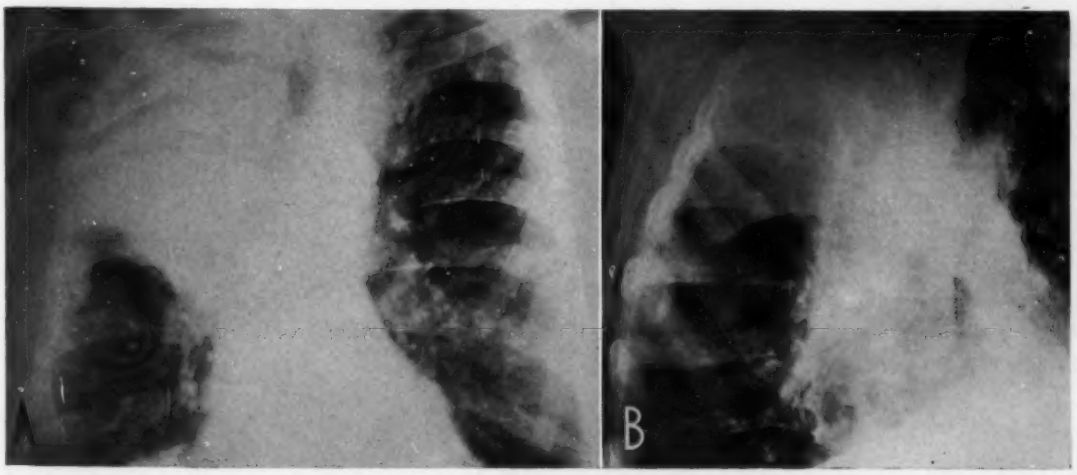

Fig. 18, *A* and *B*. The same case one month later. Now there is atelectasis of the whole upper lobe. The cancer has infiltrated the entire eparterial bronchus and thus grown centrally.

Fig. 19. The same case as Figures 17 and 18 after bronchography. The eparterial bronchus is occluded, with ragged contours.

that bronchial cancer causes more or less pronounced bronchostenosis, and that this stenosis, as I have shown in earlier papers, can be exactly localized by roentgen examination, makes it possible by repeated roentgen examinations closely to follow and study the progression of the cancer in the lung.

In my material, the bronchial cancer was localized three times as often to the right lung as to the left. Localization to the inferior lobes was somewhat more frequent than to the superior. The localization in the lung at the time each case was first examined will be seen from Figures 15 and 16. Only in one case was the primary localization to a main bronchus. In all the other cases it was to some branch of the first to third order. It is worthy of note that in all the cases where the localization was to the inferior lobes it was to the dorsal branches. In the superior lobes, on the other hand, the distribution was about evenly to the ventral and dorsal branches. In not less than 10 cases there was valve action at the first examination. In the others, the first examination showed atelectasis. In the former cases, infiltration of the lung, whether peripheral or central, could be absolutely excluded. In the latter, infiltration centrally about the stenosis could

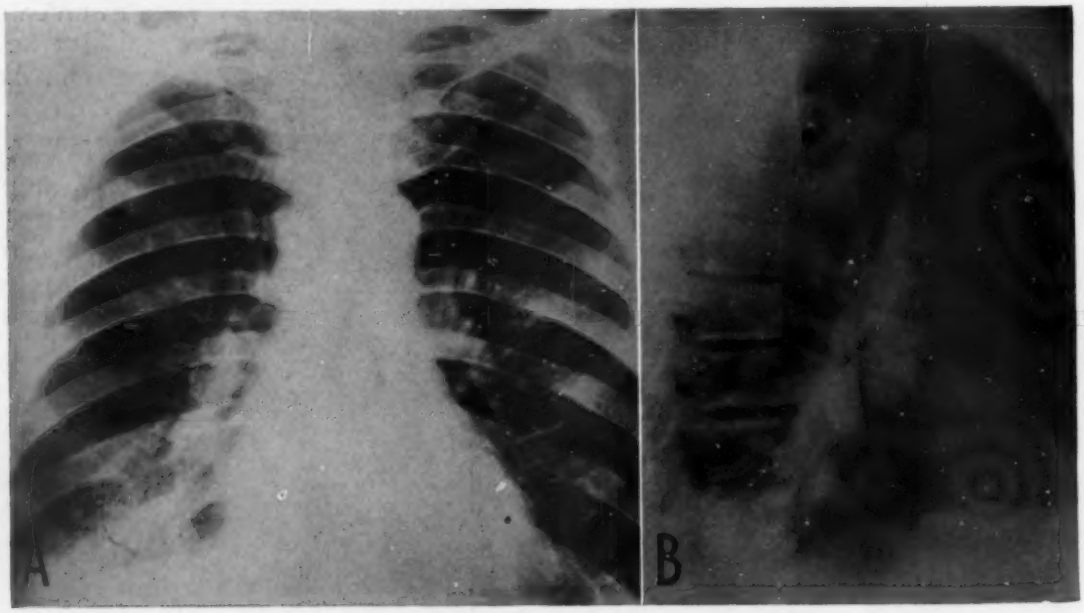

Fig. 20, *A* and *B*. Case of cancer of the third and fourth dorsal branches of the right hyparterial bronchus with atelectasis in the area corresponding to the extent of these bronchi.

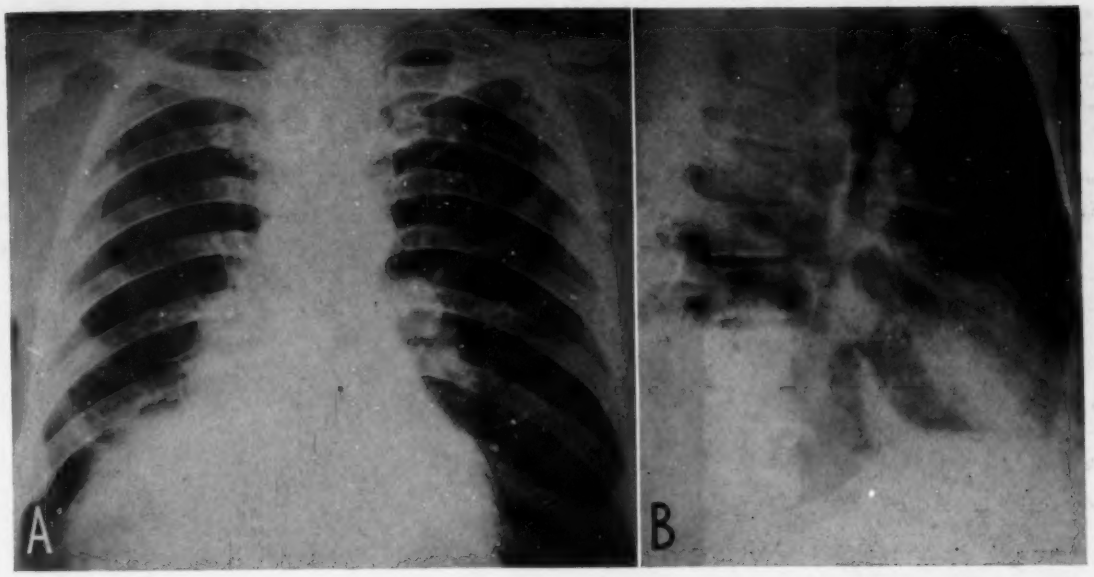

Fig. 21, *A* and *B*. The same case as Figure 20 two months later. The cancer has grown centrally and the atelectasis involves most of the lower lobe except the upper dorsal part of the lobe.

be excluded. On subsequent examinations, it was in all cases found that the stenosis had progressed centrally, so that a larger part of the lung showed signs of emphysema, or of atelectasis due to obstruction; and in the final stage the cancer had in most of the cases spread to the main bronchus, as it was verified on autopsy. It was then also found that the cancer had to a very great extent infiltrated the portion of the lung peripherally from the original stenosis.

My cases have thus shown that a bronchial cancer grows not only in a peripheral direction into the lung, but also steadily in a central direction along the bronchi and within the lung parenchyma. In this centripetal progress it is also seen secondarily to grow peripherally out into lateral bronchi situated centrally from the one originally infiltrated. This is illustrated by Figures 17–22.

The bronchial cancers in my material have thus in the great majority of cases their primary localization to the smaller bronchi, and from there the cancer will grow steadily both into the lung parenchyma and into the bronchi, both in a peripheral and a central direction. When the cancer has advanced centripetally, it afterwards continues its growth in a peripheral direction also into lateral bronchi

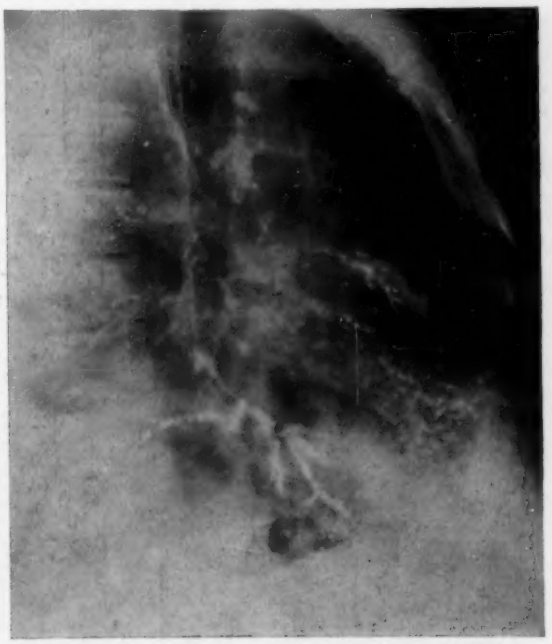

Fig. 22. The same case after bronchography. The hyparterial bronchus is occluded except the first ventral branch which is moderately stenosed.

more centrally situated. Beside this bronchogenous spread, there is also found an infiltration from the original focus out into the lung parenchyma, and infiltration into the lymph vessels. Metastases to the regional lymph nodes were found in most of the cases. In many cases also distant metastases were later formed, either in the other lobes of the same lung or in the other lung, or even in various internal organs.

That it has hitherto been overlooked that bronchial cancers thus grow from the original focus not only in a peripheral direction, but also in a central direction, towards the hilum, is probably because studies of the localization and spread of the cancer have until now been based chiefly on post-mortem material, and not on material observed for a considerable time during life.

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THE USE OF THE ROENTGEN RAY IN OBSTETRICS*

PART II. ANATOMICAL VARIATIONS IN THE FEMALE PELVIS AND THEIR CLASSIFICATION ACCORDING TO MORPHOLOGY

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I. THE ANALYSIS OF PELVIC SHAPE

FOR THE purpose of description, the pelvis is divided into the *upper pelvis* (inlet); the *midpelvis* (level of the ischial spines); the *lower posterior pelvis* (the space above the sacrococcygeal platform); and the *lower anterior pelvis or outlet* (the space in front of the sacral tip). These levels are somewhat similar to the four parallel planes of Hodge.[7] We have worked out a standard method of analysis to aid in the anatomical description of these four levels. The diagrams and accompanying legends in Figure 1 show the method used in dividing the pelvis into suitable segments and indicate the regions where deviations in shape are prone to occur.

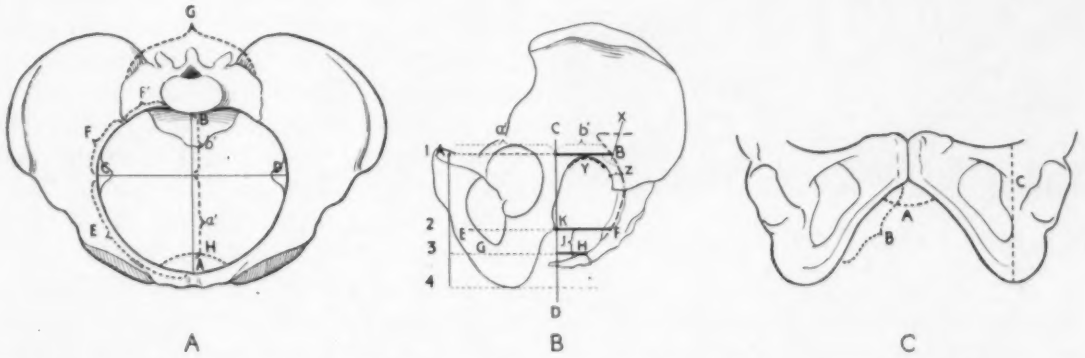


FIG. 1. *A*, analysis of pelvic capacity from the inlet view. CD—coronal plane passing through the widest transverse diameter and the ischial spines to form the anterior and posterior segments. AB—anteroposterior diameter of inlet and its two parts; the anterior and posterior sagittal diameter a′ and b′. E—anterior puboiliac boundary of the anterior segment. F—posterior iliac boundary of the posterior segment. F′—sacral portion of boundary of posterior segment variable according to width of sacrum, G. H—angle of fore pelvis behind symphysis (retropubic angle) variable according to pelvic type.

B, analysis of pelvic capacity as viewed from the lateral aspect. 1, 2, 3, 4—parallel pelvic planes. CD—coronal plane through widest transverse diameter of inlet and the interspinous diameter at right angles to the parallel pelvic planes. AB—anteroposterior diameter of inlet with the anterior and posterior sagittal diameters a′ and b′. Y—size and shape of sacrosciatic notch. Variable according to pelvic type. Z—section of ilium which may preserve good length to posterior sagittal diameter (b′) in spite of a narrow sacrosciatic notch. X—inclination of the sacrum, the size of the angle subtended by the plane of the inlet AB and the upper surface of the sacrum. KF—posterior sagittal at level of ischial spines. GH—anteroposterior diameter of outlet in front of the sacral tip. Note the level of the sacrococcygeal platform to the plane of the spines at J. Note length of posterior sagittal at level of 3rd plane (heavy part of line GH).

C, analysis of pelvic capacity front view. A—angle of subpubic arch. Variable in size and shape. B—variations in curvature of pubic rami. C—depth of true pelvis.

The pelvis is divided into an anterior and posterior segment by a coronal plane passing through the widest transverse diameter

* From the Departments of Obstetrics and Gynecology and of Radiology, College of Physicians and Surgeons, Columbia University, and Sloane Hospital for Women, and the Department of Radiology of the Presbyterian Hospital, New York. Read in part at the Thirty-fifth Annual Meeting, American Roentgen Ray Society, Pittsburgh, Pa., Sept. 25–28, 1934, and at the Thirty-sixth Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 24–27, 1935.

FIG. 2. Analysis of the lateral roentgenogram. The plane of the inlet is located by means of the white line. The coronal plane passes through the widest transverse diameter of the inlet and the spine at right angles to the parallel pelvic planes. The lengths of the anterior and posterior sagittal diameters at and below the inlet can be seen. The influence of sacral curvature and inclination upon posterior pelvic space is indicated by the length of the posterior sagittal at the level of the spines and the level of the sacrococcygeal platform below. AB—anteroposterior diameter of inlet and first pelvic plane. CD—coronal plane through the widest transverse diameter and the interspinous diameter. a′—anterior sagittal diameter. b′—posterior sagittal diameter. x—inclination of sacrum. yz—sacrosciatic notch. KF—posterior sagittal at level of spines (second plane). GH—anteroposterior diameter of outlet (third plane). J—relationship of level of spines and sacrococcygeal platform. The two heavy arrows indicate the wing-shaped mastoid densities useful in determining the obstetrical position of the head. A line bisecting the angle between these densities also bisects the occipital bone.

of the inlet and through the interspinous diameter (Fig. 1, *A* and *B*). All anteroposterior diameters below the inlet are thus divided into two parts, an anterior sagittal diameter and a posterior sagittal diameter. Hitherto the terms *anterior* and *posterior sagittal diameters* have been used to define the distance between the under surface of the symphysis and the midpoint of the intertuberous diameter (anterior sagittal) and from this point to the tip of the sacrum (posterior sagittal). We believe that these terms can also be applied to the two parts of anteroposterior diameters for each level of the pelvis as divided by the coronal plane (Fig. 1, *B*).

At the inlet the lengths of the anterior and posterior sagittal diameters and the widest transverse diameter vary according to the basic inlet type. Below the inlet, variations in the boundaries of the true pelvis may exist because of changes in pelvic shape as the outlet is approached. Thus the anterior and posterior sagittal diameters at lower levels are affected by variations in the inclination and curvature of the sacrum behind and the inclination of the symphysis and pubic rami in front. Transverse diameters from the inlet to the tuberosities of the ischium are influenced by the splay of the side walls of the pelvis, the length of the ischial spines, and the size and shape of the subpubic arch (Fig. 1, *A* and *C*).

The pelvic outlet has never been clearly defined. Three bony anatomical landmarks enter into its formation, the two ischial tuberosities, and the tip of the sacrum, the latter situated at a higher level. The tuberosities of the ischium, denoting the lowest pelvic plane, are below and in front of the ischial spines. The bony outlet is most satisfactorily described by reference to its form in front of the sacrococcygeal platform. The anteroposterior diameter of the outlet extends forward as the third parallel plane into the free space of the subpubic arch (GH, Figs. 1, *B*, and 2). The transverse diameter of the outlet at this level is situated just above the ischial tuberosities on the flat pelvic surface of the ischium.

The sagittal plane of the pelvic cavity from inlet to outlet approaches the shape of a parallelogram, being as deep behind the pubis as in front of the sacrum. The free space of the subpubic arch does not become available for the head until the

head is low on the pelvic floor in the fore pelvis.

The schematic analysis outlined in Figure 1, *B*, can be applied to the lateral roentgenogram as an aid in the study of pelvic capacity for sagittal diameters (Fig. 2). The chief difficulty is in locating the plane of the inlet and the posterior point of the anteroposterior diameter. Obstetricians persist in using the promontory as the posterior origin of the anteroposterior diameter in spite of the fact that it is most variable in relation to this first plane of the inlet. In the lateral roentgenogram (Fig. 2), the point where the plane of the inlet cuts the sacrum is located by means of the dense white line which is produced by the posterior aspects of the ilium and the sacral alae above the apex of the sacrosciatic notch. This line, for practical purposes, coincides with a continuation of the iliopectineal lines from either side to their point of intersection on the anterior surface of the first sacral segment. A continuation of the white line forward usually touches the posterior-superior curved aspect of the symphysis. Not infrequently the sacral origin of the anteroposterior diameter is situated below this white line, as indicated in Figure 3. The coronal plane passing upward from the ischial spines at right angles to the anteroposterior diameter of the inlet locates the point of intersection of the widest transverse diameter and the anteroposterior diameter of the inlet. Unless the plane of the inlet has been accurately determined the coronal plane from the ischial spines may cross in front of the proper intersection of the anteroposterior and widest transverse diameters of the inlet. As a result, the sagittal diameters so formed are not suitable in all instances for quantitative measurement in the lateral roentgenogram. As soon as the anteroposterior diameter and the coronal plane are marked on the film, the lengths of the anterior and posterior sagittal diameters at the inlet are shown. The available posterior pelvic capacity may be seen especially in regard to the relationship of

Fig. 3. Skeletal example to show unusually low first plane of the inlet. The sacral point of origin of the anteroposterior diameter is actually *below* the section of ilium and portion of sacral alae which produces the so-called white line in the lateral roentgenogram, a.

sacral curvature and inclination to the ischial spines.

2. A CLASSIFICATION OF PELVES ACCORDING TO SHAPE

Pelves are classified according to the shape of the inlet in association with a description of the boundaries of the true pelvis at lower levels. We have selected four standard parent or pure types to form the basis for a simplified morphologic classification and have proposed a terminology which describes the shape of these four types. By suitable combination, these terms also describe the shape of the mixed, or borderline forms. The use of one of these terms by itself indicates a parent or true type in which the combined shape of the anterior and posterior segment conforms to the classical longitudinal oval, the round, the transverse oval, or the wedge-shaped type of inlet. One reason for division of the inlet into an anterior and posterior segment is revealed in the classi-

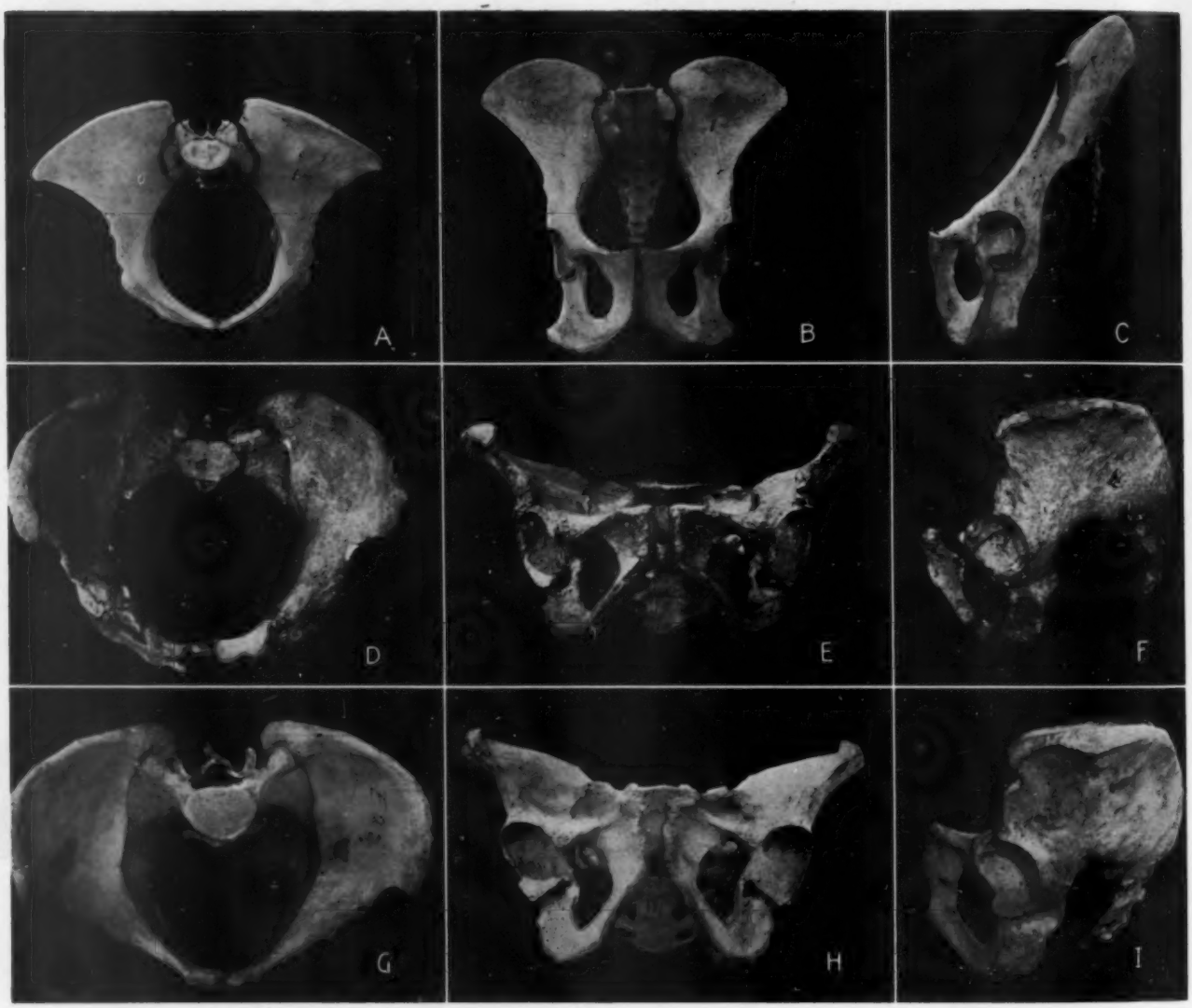


FIG. 4.* *A*, inlet view of the pelvis of a chimpanzee; *B*, anteroposterior view of the pelvis of a chimpanzee; *C*, lateral view of the pelvis of a chimpanzee; *D*†, inlet view of a normal female pelvis; *E*†, anteroposterior view of a normal female pelvis; *F*†, lateral view of a normal female pelvis; *G*†, inlet view of a normal male pelvis; *H*†, anteroposterior view of a normal male pelvis; *I*, lateral view of a normal male pelvis.

* Courtesy of American Museum of Natural History. † Courtesy of *Am. J. Obst. & Gynec.*

fication of the mixed or borderline types. The posterior segment is formed by the sacrum and a portion of the two iliac bones in the region of the sacrosciatic notch. The anterior segment of the inlet is formed by a small portion of both ilia along with the pubes. Accordingly, the posterior segment may conform in shape to one standard type and the anterior segment to another, producing mixed, or borderline forms. In the classification of these mixed types, the first term used indicates the shape of the posterior segment and the second term the shape of the anterior segment. This method is described and illustrated in greater detail in a later section of this report. The longitudinal oval, the round, the transverse oval, and the wedge-shaped inlet have been selected to form the basis for a classification because these shapes in the classi-

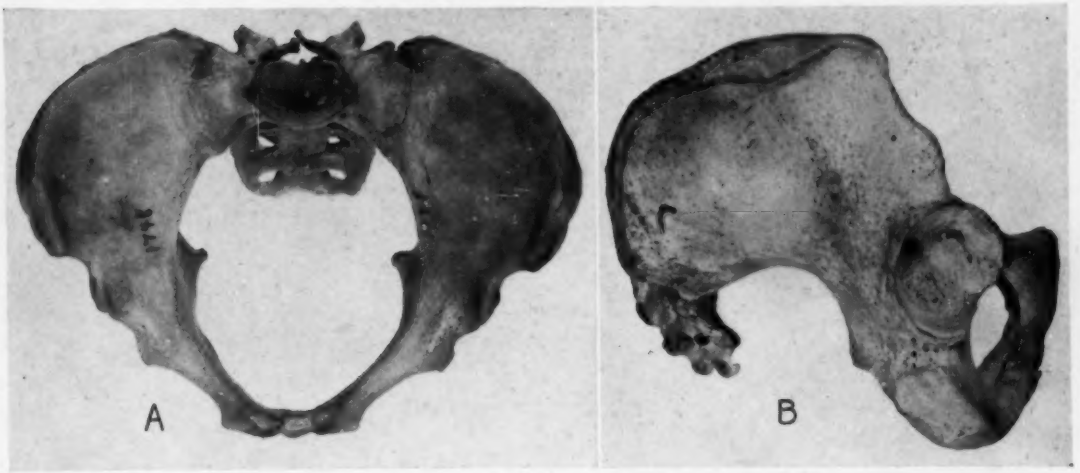


FIG. 5.* The anthropoid type of pelvis. *A*, inlet view of an extreme anthropoid human type of pelvis; *B*, lateral view of an extreme anthropoid human type of pelvis.

* Courtesy of Professor T. Wingate Todd and *Am. J. Obst. & Gynec.*

cal examples exert the maximum influence upon the position of the head as it descends. For instance, the longitudinal oval shape aids engagement of the fetal head in the anterior or posterior oblique position, the transverse oval in the transverse position.

(1) The Anthropoid Type (G. *Anthrōpos*, man+lidos, resemblance). This pelvis closely resembles the shape of the pelvis of the anthropoid apes and presents a long, narrow, oval shape (Fig. 5).

(2) The Gynecoid Type (G. *Gynē*—woman). This type refers to the normal female pelvis, which presents all the well-known female sex architectural characteristics. The form of the inlet is round (Fig. 4, *D*, *E* and *F*).

(3) The Platypelloid Type (G. *Platys*—flat; *pellis*—pelvis). This pelvis is essentially human in character and presents a wide or transverse oval appearance (Fig. 6). It is, in fact, more characteristically human than, for instance, the anthropoid type of human pelvis.

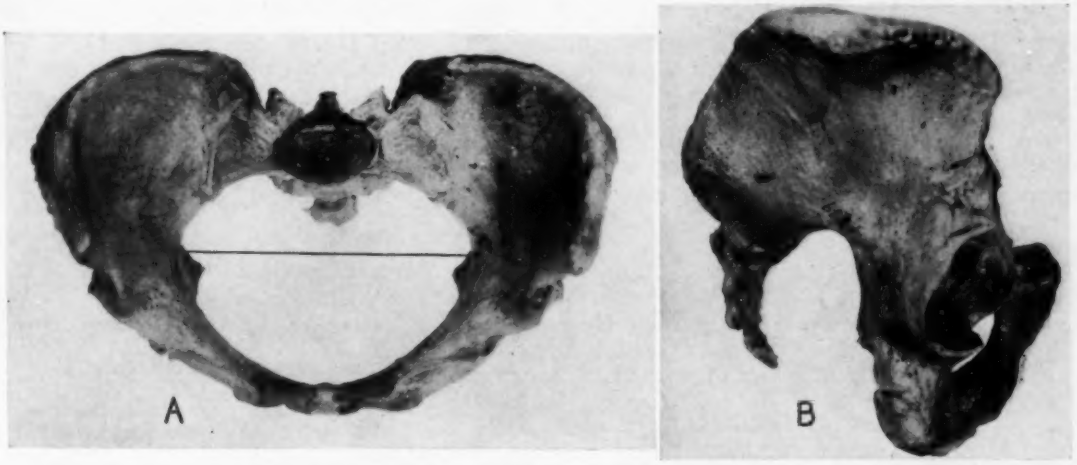


FIG. 6.* The platypelloid type of pelvis. *A*, inlet view of a typical platypelloid (flat) type of pelvis; *B*, lateral view of a typical platypelloid (flat) type of pelvis.

* Courtesy of Professor T. Wingate Todd and *Am. J. Obst. & Gynec.*

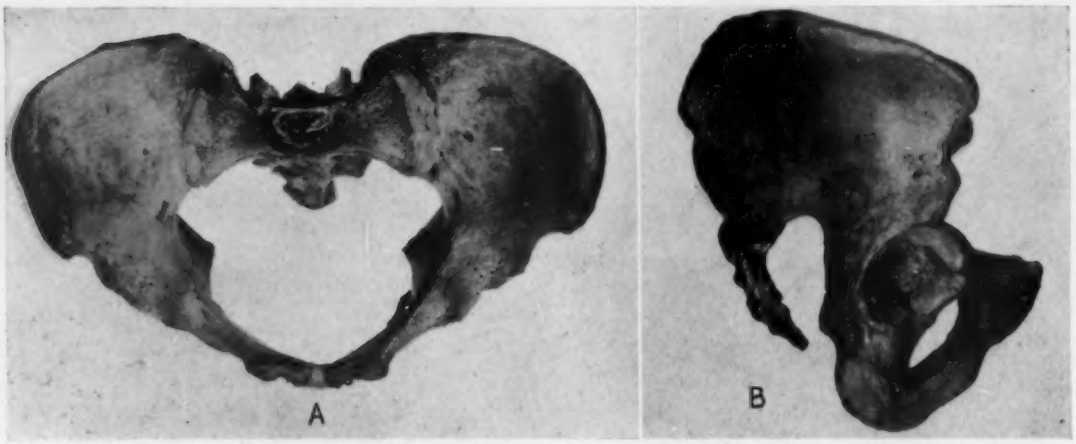


Fig. 7.* The android type of pelvis. *A*, inlet view of typical android type of female pelvis; *B*, lateral view of typical android type of female pelvis.

* Courtesy of Professor T. Wingate Todd and *Am. J. Obst. & Gynec.*

(4) The Android Type (G. *Anēr*—man). This pelvis bears a morphological resemblance to the human male pelvis (Fig. 7). The inlet is wedge shaped or blunt heart shaped.

These four types have been recognized by anatomists and anthropologists. At least the descriptive terms used by Weber[20] and von Stein[16] would lead us to believe that these types formed the basis for their anatomical classification. Turner[19] in 1885 described racial characteristics and suggested terms to designate the long oval, the round, and the flat type, but he did not describe the important masculine form of female pelvis (android) because he devised his classification from the study of male pelves. He did this in order to avoid the influence which caused an overlapping of the sexual characteristics to produce the masculine type in the female pelvis. A comparison of morphologic classifications is shown in Table I.

Weber did not define clearly the characteristics of his four-sided and wedge-shaped types. For instance, in the four-sided pelvis, Weber stated that the transverse diameter exceeded the anteroposterior diameter, but we place this type in the anthropoid class because such quadrangular pelves appear to have an anthropoid appearance (see the mixed type of pelvis *G*, Fig. 10). The wedge-shaped type of Weber was not distinguished clearly from the anthropoid group, because Weber considered that the transverse diameters were diminished in spite of the fact that the wedge-shaped character of the inlet places the type in a distinct group by itself, the android group. Stein also divided pelves

Table I

A comparison of morphologic classifications

Caldwell and Moloy	Weber (1830)	von Stein (1844)	Turner (1885)
(1) The anthropoid	four sided	longitudinal-elliptical	dolichopellic
(2) The gynecoid	round	round	mesatipellic
(3) The android	wedge shaped	truncated-cordate	not described
(4) The platypelloid	oval	transverse-elliptical	platypellic

into four groups, but like Weber, he does not appear to refer these differences to a common standard.

We have already pointed out that the relationship of the widest transverse diameter to the anteroposterior diameter of the inlet (pelvic index) often fails to indicate the true shape of the pelvic inlet (Fig. 2, *A*, Part 1). If the form of the male inlet is studied aside from the question of inlet measurements, a characteristic wedge-shaped type will be recognized which is not included in Turner's three groups. Thus male pelves can be likewise divided into four standard inlet shapes similar to the suggested classification for female pelves. The practicability of this classification of male pelves has been proved to our satisfaction by the study of plaster casts of the pelvic inlet prepared by Professor T. Wingate Todd from the wet torso before maceration. The frequency of occurrence of each type in this small series of 11 inlet casts is shown in Table II.

This observation suggests that the characteristic male inlet is wedge shaped rather than a long oval. This fact is also shown in the average measurement of male inlets given in Table IV. This observation may be used to explain the practical value of the terminology we have suggested. The term "anthropoid" is used to refer to a long oval type of pelvis, male or female. The term "gynecoid" is used to indicate a round (woman-like) pelvis for both sexes. The term "android" is used to designate the characteristic wedge-shaped (man-like) inlet for both sexes. The term "platypelloid," originally suggested by Turner, correctly designates the flat or transverse oval pelvis for both sexes. The classification of pelves described by Weber, von Stein and Turner makes no provision for the classification of the important and numerous borderline or mixed forms.

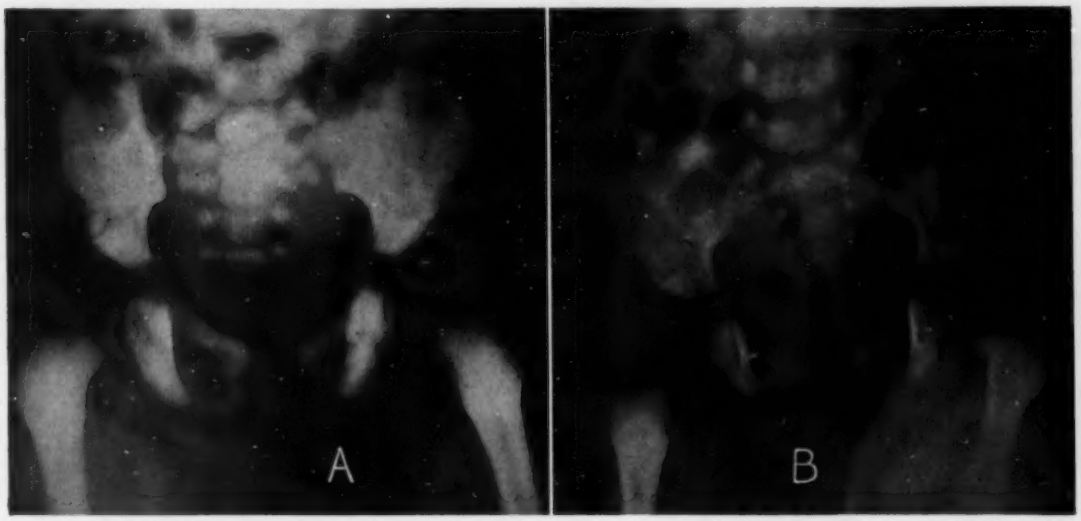


Fig. 8. Roentgenograms of the pelvis of the newborn female child to show variations in the shape of the pelvic inlet. *A*, the shape of the inlet conforms to the blunt heart-shaped or the android-gynecoid type; *B*, the inlet in this example is round or tends to the long oval anthropoid type.

Table II

CLASSIFICATION OF PLASTER CASTS OF THE MALE INLET

	White	Negro	Total
Anthropoid (long oval)	0	2	2
Gynecoid (round)	2	0	2
Android (wedge shaped)	2	3	5
Platypelloid (flat)	2	0	2

In recent years the anthropological reports of Smith and Wood-Jones,[15] Hrdlička,[9] Hooton,[8] Reynolds,[13] Derry,[2] and many others, have drawn attention to the frequent occurrence of masculine characteristics in female pelves. These departures in shape from the well-known female characteristics make the diagnosis of the sex of unknown skeletal material exceedingly difficult, if not impossible, in many examples encountered by field workers.

Obstetricians (Dewees,[3] Murphy,[11] Leishman,[10] Hart,[6] Fabre and Trillat,[4] Thoms,[18] in this country, and others) from time to time have recognized and described extreme anthropoid and android types, and in certain instances have accurately discussed the mechanism of labor for each. For instance, Dewees described anterior manual rotation of a head arrested in the transverse position at the inlet in what would seem to be a typical anthropoid type of pelvis in order to allow the head to utilize the more ample anteroposterior diameter.

These abnormal-shaped pelves, however, were usually considered as distinctly pathological and rare in occurrence. Only by roentgenological methods of examination has it been possible to show the frequency of occurrence and great significance of these anatomical variations in the causation of many minor and major obstetrical difficulties in routine practice, especially the "low transverse arrest" or "persistent occipitoposterior position."

Typical Anthropoid Characteristics (Pelvis of the Chimpanzee) (Fig. 4, A, B and C). The accompanying photographs of the pelvis of a female chimpanzee reveal the classical anthropoid characteristics. The inlet is a long, narrow oval, but the transverse measurements are ample in spite of the relative narrowing. The posterior iliac portion of the inlet over the shallow but wide sacrosciatic notch is long (Fig. 4, *C*). In the example shown, the angle of the fore pelvis is wide; but in the other examples, sharp narrowing may be present near the symphysis. The subpubic arch exists as a narrow incisura under the wide heavy symphysis (Fig. 4, *B*). The lateral view shows the marked pelvic obliquity as well as the upright sacrum with the symphysis parallel to it, but at a considerably lower level (Fig. 4, *C*). The long narrow six-segmented "anthropoid" sacrum is illustrated clearly in Figure 4, *B*.

Human Anthropoid Types. Human pelves which bear a resemblance to the pelvic form of the higher apes are termed "anthropoid" types and have been referred to as the "transversely-contracted pelvis" or the "assimilation pelvis" by Breus and Kolisko.[1] The anatomic characteristics are illustrated in Figure 5. A comparison with Figure 4 will reveal the similarity to the pelvic form of the anthropoid apes. The anteroposterior diameter is long and the transverse diameter relatively or absolutely narrowed. In the more extreme examples the anteroposterior diameter equals or exceeds the length of the transverse diameter of the inlet. The angle of the fore pelvis at the inlet may be long and narrow or average in size. The widest transverse diameter is placed considerably in advance of the sacral promontory since the posterior iliac portion of the inlet is very long (see Fig. 1, *A*). This produces a wide sacrosciatic notch (Fig. 5, *B*). In the typical examples the sacrum is long and narrow and may consist of six segments. It articulates with the ilium at the most distal aspect of the posterior edge of the iliac crest (Fig. 5, *B*). In the upright posture the inclination of the inlet in anthropoid types is almost perpendicular to the horizontal plane or in the supine position, parallel with the horizontal plane. The subpubic angle is usually moderate to wide. Narrow arches and narrow fore pelves may occur, but for the most part, such extreme examples are found in women not normal enough to become pregnant and may be found in the endocrine or sterility clinics.

The Typical Gynecoid (Female) Characteristics (Fig. 4, D, E and F). The term "gynecoid" literally refers to female characters in male pelves, but we use it to desig-

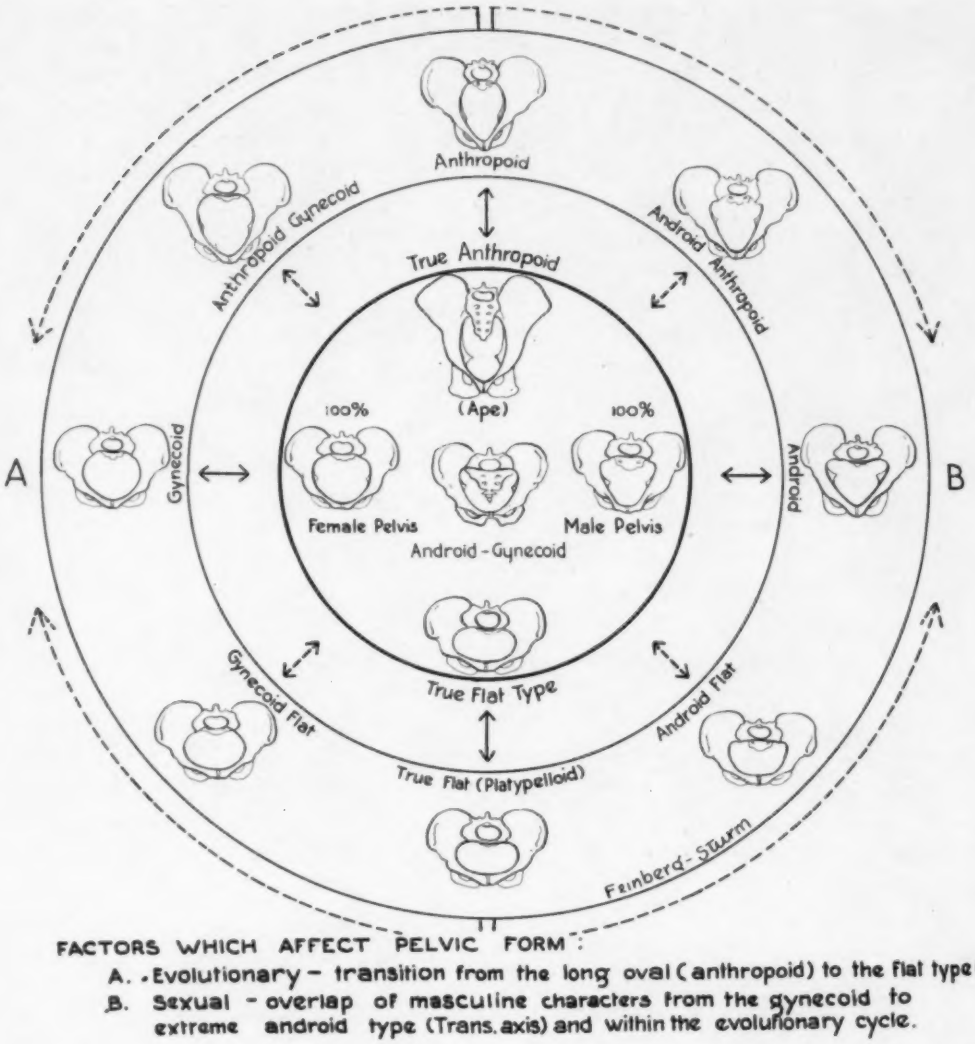
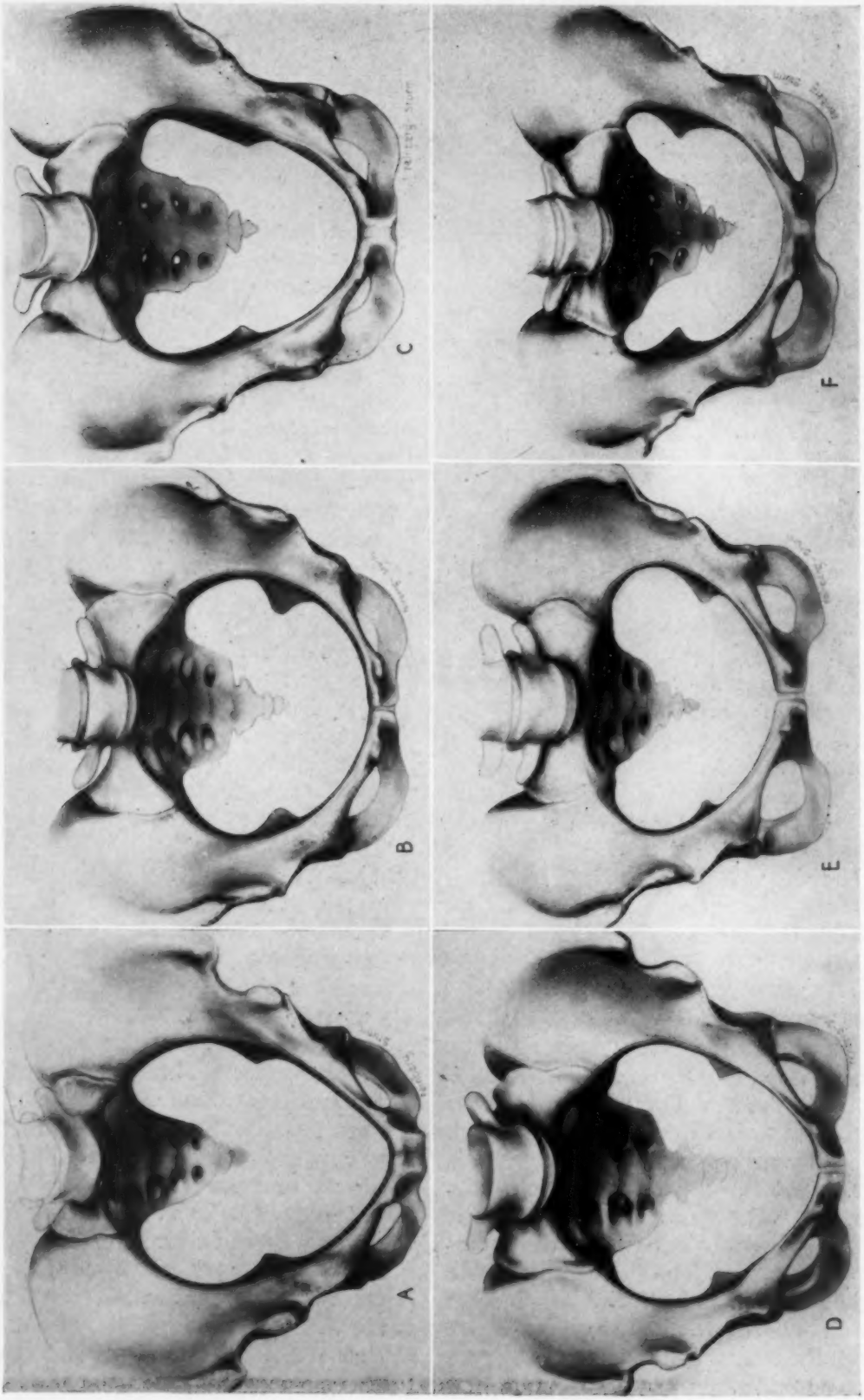


FIG. 9.* Diagram to show the gradation of change in pelvic form from a longitudinal oval to a transverse oval, the presence of masculine characteristics and the relation of borderline or mixed forms to the parent four types.

* Courtesy of *Am. J. Obst. & Gynec.* (modified slightly from original published diagram).

nate the "round" or "woman-like" form of pelvis for both sexes. The ratio between the inlet diameters is approximately 11 to 13. In the extreme gynecoid type, the inlet is well curved and capacious in both segments. The widest transverse diameter is placed considerably anterior to the promontory (Fig. 4, *D*). The sacrosciatic notch and the posterior iliac portion of the inlet at the apex of the notch are average in size (Fig. 4, *F*). The sacrum slopes backward, creating a wide sacrosciatic aperture and insuring ample space in the posterior pelvis The bones are of average thickness.

The subpubic arch is wide and the pubic rami reveal "a Norman-arch effect" as a result of the concavity caused by the free edge (Fig. 4, *E*). This feature is caused by the origin of the descending pubic rami from the inferior lateral aspect of the symphysis pubis. The side walls of the pelvis are straight, preserving down to the intertuberous and interspinous diameters the transverse capacity present at the inlet.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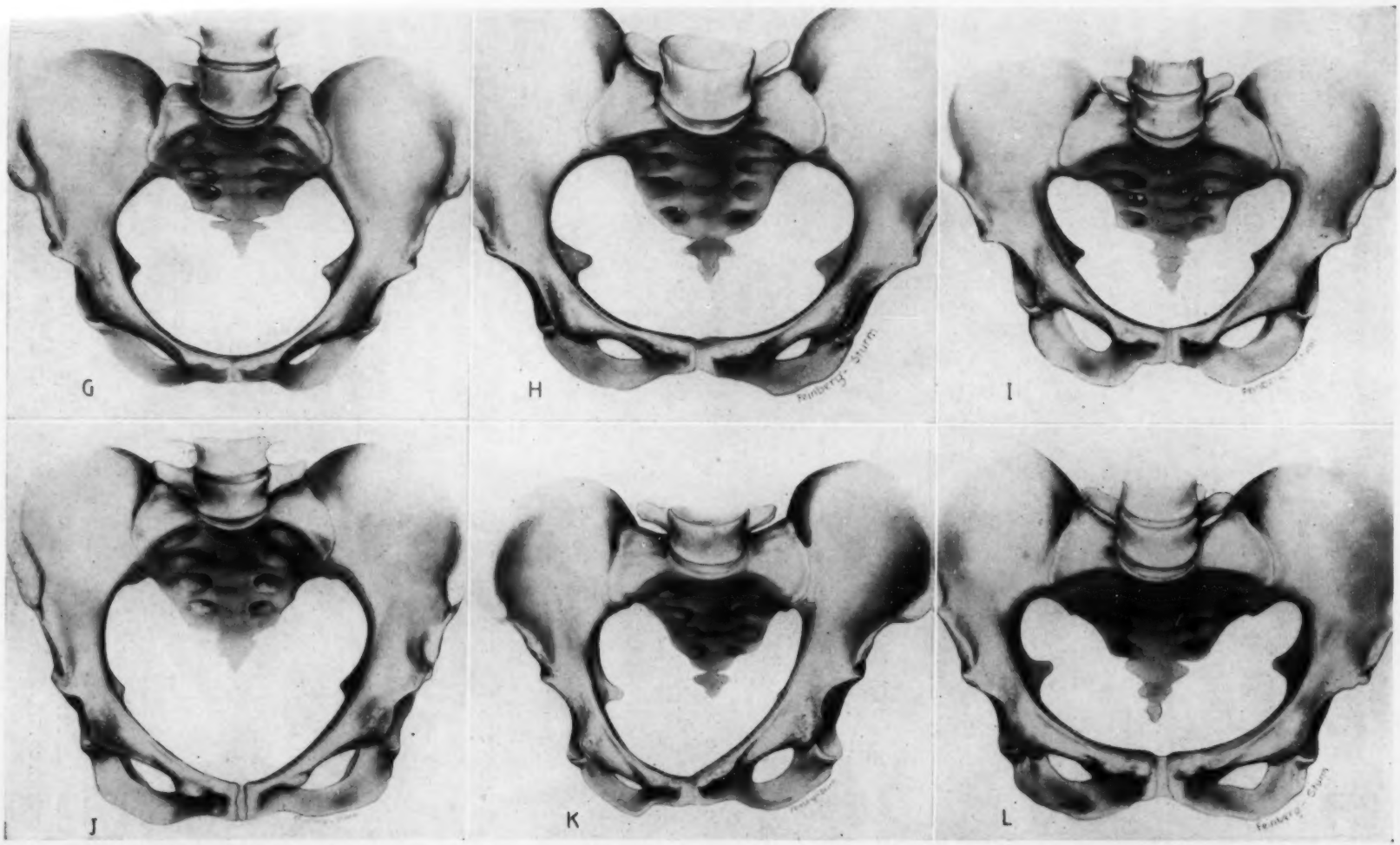

FIG. 10.* Diagrams of the four parent forms and the common borderline types. The examples shown in *D*, *G*, and *J* should all be grouped in the anthropoid-gynecoid class for the sake of simplicity. *A*, true anthropoid type (parent type); *B*, true gynecoid type (parent type); *C*, android-anthropoid type (mixed form); *D*, anthropoid-gynecoid type (mixed form); *E*, gynecoid-flat type (mixed form); *F*, android-gynecoid type (mixed form); *G*, gynecoid-anthropoid type (mixed form) somewhat similar to the four-sided type of Weber; *H*, true platypelloid (flat) type (parent type); *I*, true android type (parent type); *J*, gynecoid with a narrow fore pelvis (mixed type); *K*, asymmetrical type; *L*, android-flat type (mixed form).

* Courtesy of *Am. J. Obst. & Gynec.* and constructed by use of stereoroentgenograms and photographs obtained from Professor T. Wingate Todd.

Platypelloid (Flat) Characteristics (Fig. 6, A and B). Flattening of the pelvic inlet is characteristically a human skeletal peculiarity. The anteroposterior diameters are short, the transverse wide. In the characteristic example as shown, the inlet, in spite of the flatness, is smoothly formed, showing no sharp angles. The widest transverse diameter tends to be placed midway between symphysis and promontory. The sacrosciatic notch may appear small as a result of foreshortening due to the anteroposterior flattening throughout the pelvis (Fig. 6, *B*). The subpubic arch and lower pelvis usually conform to the female type just described but any degree of narrowing or convergence of the lateral pelvic walls may be found in the individual case. The pelvis which possesses these extreme flat characteristics may be termed the "platypelloid" type, or, in ordinary language, the "flat" type.

The Android Characteristics (Fig. 4, G, H and I). The male inlet is correctly termed "wedge shaped." The angle of the fore pelvis at the inlet is narrow (Fig. 4, *G*). The iliopectineal lines extend straight backward from the symphysis to the widest transverse diameter, at which point they turn acutely inward to the sacroiliac joint. As a result, the widest transverse diameter is situated close to the sacrum, and the posterior iliac portion of the inlet is short. This latter feature also affects the sacrosciatic notch, which appears narrow from the lateral aspect (Fig. 4, *I*). The sacrum is inclined forward in the posterior pelvis approaching the ischial spines. The subpubic arch is narrow with straight pubic rami arising from the under surface of a characteristic wedge-shaped pubis (Fig. 4, *H*). The side walls converge toward the narrow subpubic arch. The bones are heavy and angular, and the true pelvic cavity is deep.

The Android Type in the Female (Fig. 7). Female pelves which approach the shape of the male pelvis are called "android" types. The term "android" is used, therefore, to designate the pelvis which reveals a wedge-shaped inlet (Fig. 7, *A*) with a flat posterior segment and a narrow masculine type of sacrosciatic notch (Fig. 7, *B*). Convergence of the side walls to a narrow subpubic arch, though commonly found in android types, represents a masculine characteristic which may occur in other forms. The parent or pure android type, as illustrated in Figure 7, may, of course, so closely approach the shape of the male pelvis that the external genitals alone designate the true sex of the individual. Such extreme forms in living women comparable to the examples described by Smith and Wood-Jones[15] are found in cases of primary amenorrhea and seem to justify the assumption of a sexual or hormonal etiological influence.

Fehling[5] and Thompson[17] have shown that many of the sexual differences as illustrated and described for the typical male and female pelves can be recognized in the fetal pelvis early in intrauterine life. Recently we have studied the roentgenologic appearance of the fetal pelvis shortly after birth. In addition to the recognition of sexual differences, we have observed variations in inlet shapes in the female child which suggest anthropoid and android types (Fig. 8).

Intermediate, Borderline, or Mixed Pelvic Types. Pelvic shape appears to be affected by two distinct and radically different factors. The first may be termed the "evolutionary influence" and refers to the transition from a long narrow oval through a round form to a transverse oval or flat type (Fig. 9, left section of outer circle). The second factor concerns the occurrence of masculine characteristics in female pelves without regard to the particular shape of the inlet in respect to its position within the cycle of change just referred to. This second factor has been termed the "sexual or hormonal influence." We have used the characteristic long oval, round, flat, and wedge-shaped inlets to form the parent or standard types, using the shape of the posterior segment of the inlet to designate the classification of each pelvis. Accordingly, in the classification o

pelves which in shape blend with one or the other of these four parent types, the shape of the posterior pelvis is used to designate the correct term. The first term refers to the posterior pelvis and the second to the anterior pelvis. Thus the term "android-gynecoid" refers to a pelvis with a flat masculine type of posterior segment associated with a well formed fore pelvis. The term "android-anthropoid" designates a long, narrow, wedge-shaped inlet caused by a flat masculine type of posterior pelvis behind the widest transverse diameter and a long narrow fore pelvis in front giving it an anthropoid appearance. For simplicity we have described five borderline, or mixed types, the anthropoid-gynecoid, the gynecoid-flat, the android-anthropoid, the android-flat, and the android-gynecoid. These terms are frequently used in the routine description of pelves. The term "flat" is preferable to the term "platypelloid" when reference is made to the presence of a flat tendency in the mixed forms. A study of Figure 10 will indicate the shape of these intermediate types and the method used in their classification from the standpoint of terminology.

The markedly distorted pelves caused by rickets, sacroiliac disease in childhood, and congenital or other abnormalities will be encountered occasionally. Two excellent examples of such abnormal pelves are shown in Figure 11.

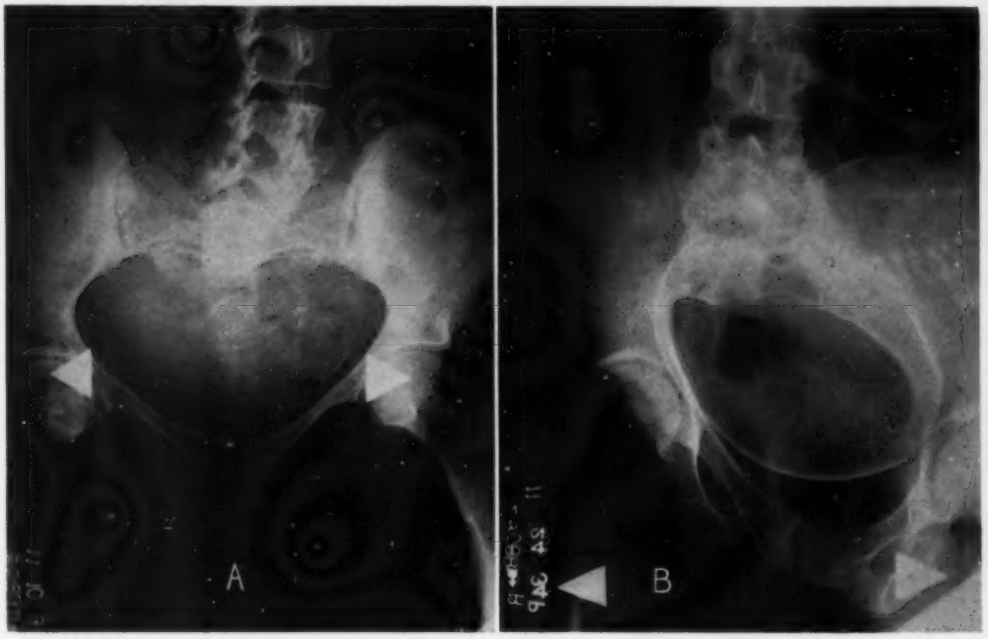

Fig. 11. The pathological pelvis. *A*, rachitic flat pelvis. Caesarean section at term; *B*, obliquely contracted pelvis. Nägele's pelvis caused by tuberculosis of right sacroiliac synchondrosis in childhood. Caesarean section at term.

3. THE LOWER PELVIS

The Subpubic Arch and Side Walls. The subpubic arch may vary in size and shape irrespective of pelvic type. Wide, moderate, and narrow arches, with variations in the character of the free edge of the pubic rami and the bone weight, are recognized easily (Fig. 12). The splay of the side walls of the pelvis is also quite variable, and convergent, straight, and divergent ("blunderbuss shape" as viewed from the front) forms occur (Fig. 13). Convergence may involve only the midischial plane because of a bulging inward of the ischial spine on a broad base, while a straight lateral wall

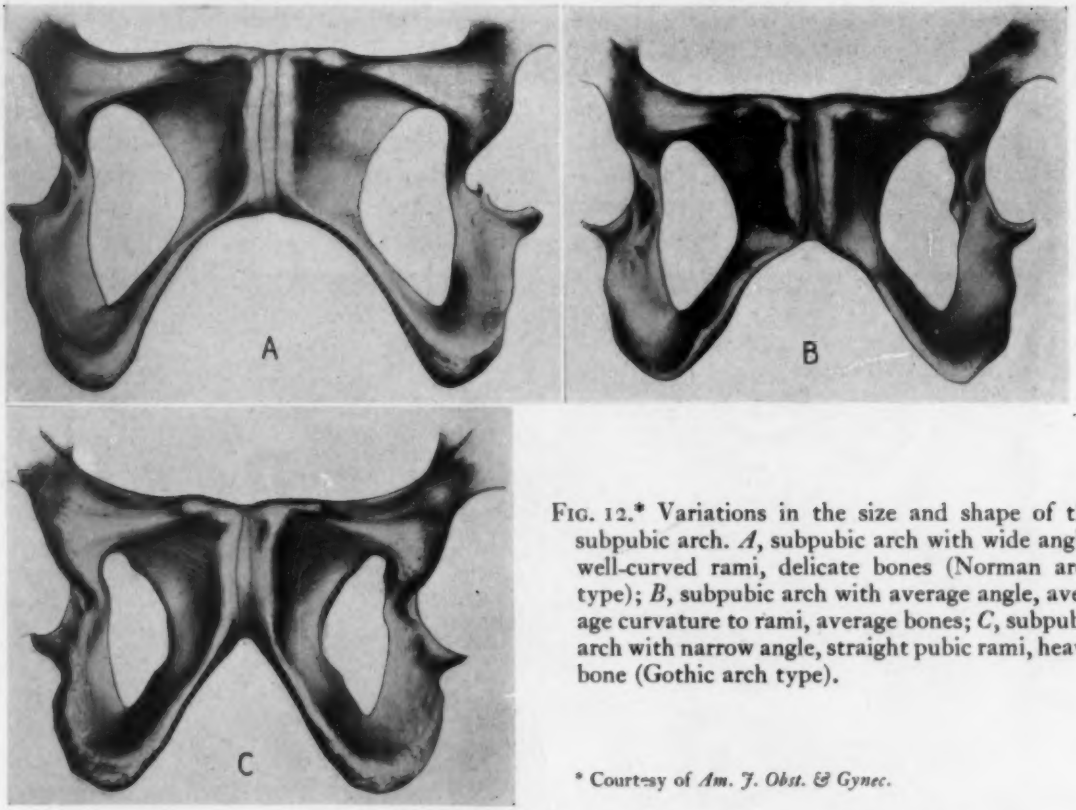

Fig. 12.* Variations in the size and shape of the subpubic arch. *A*, subpubic arch with wide angle, well-curved rami, delicate bones (Norman arch type); *B*, subpubic arch with average angle, average curvature to rami, average bones; *C*, subpubic arch with narrow angle, straight pubic rami, heavy bone (Gothic arch type).

* Courtesy of *Am. J. Obst. & Gynec.*

from the inlet maintains a wide intertuberous diameter at lower levels. In other instances, the convergence may involve both the ischial spines and tuberosities, and the entire lateral wall may slope inward to create a funnel-shaped fore pelvis. As a

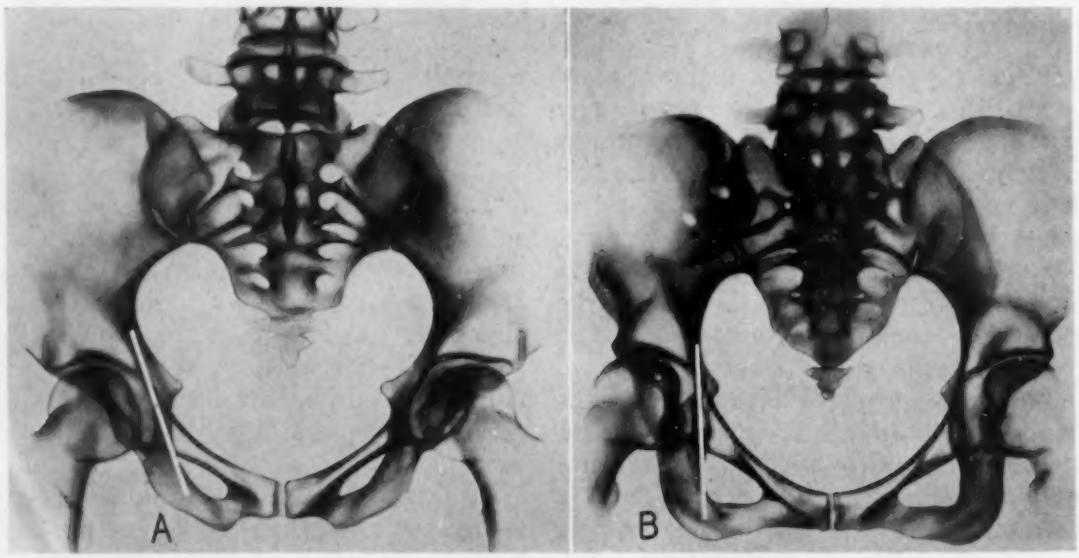

Fig. 13.* Splay of side walls of pelvis. *A*, convergent type; *B*, divergent type (blunderbuss form).

* Courtesy of *Am. J. Obst. & Gynec.*

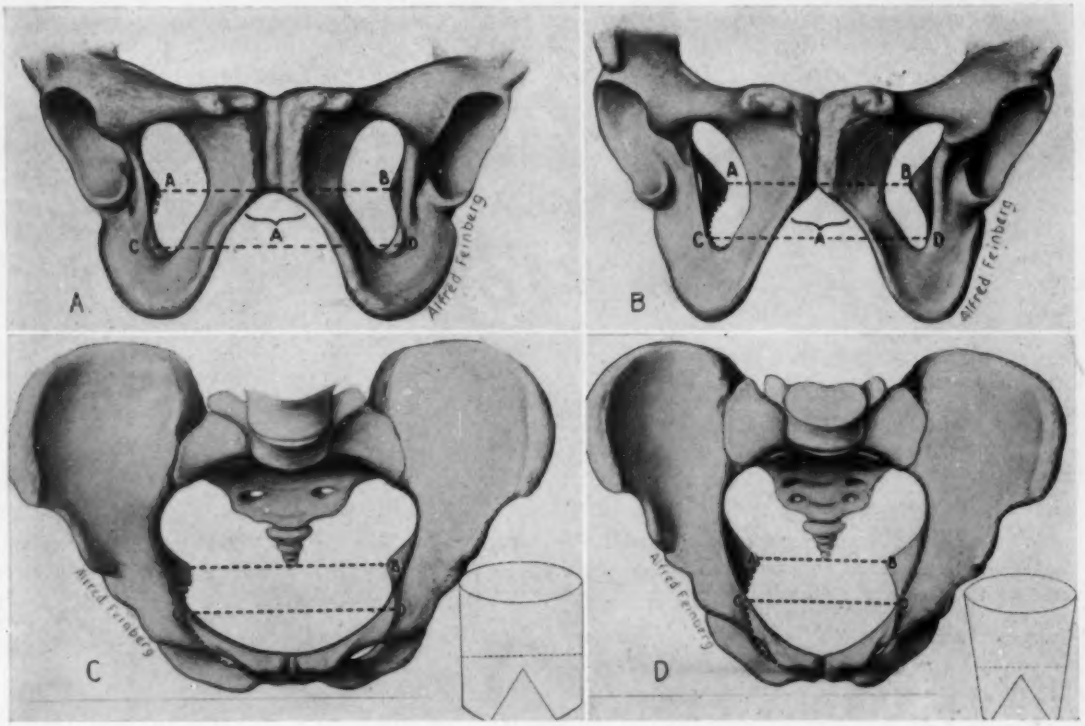

Fig. 14.* Diagram to show a narrow subpubic arch alone is no reliable index to the basic pelvic type. *A*, narrow subpubic notch; *B*, equally narrowed subpubic arch; *C*, wide transverse diameters, android flat type; spontaneous delivery in spite of narrow subpubic arch (A); *D*, convergent side walls with narrow transverse diameters in an android-anthropoid type. Medium forceps delivery of a small child.

* Courtesy of *Am. J. Obst. & Gynec.*

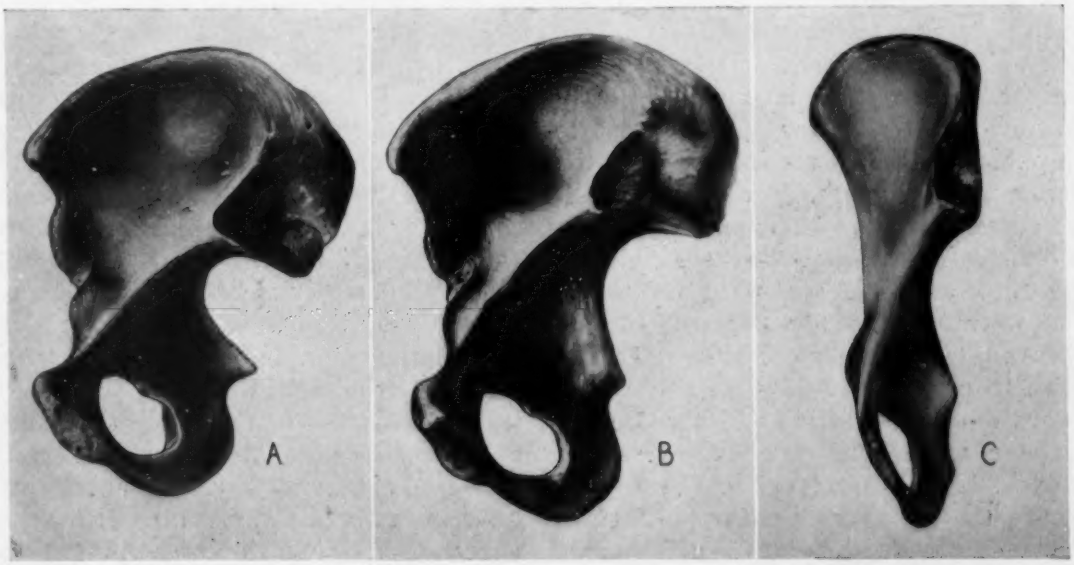

Fig. 15.* Variations in the ischial spines. *A*, average sharp type—long or short; *B*, anthropoid type on a broad base; *C*, ischial bulge of the pelvis of a chimpanzee. (Drawn from photographs by courtesy of Professor T. Wingate Todd.)

* Courtesy of *Am. J. Obst. & Gynec.*

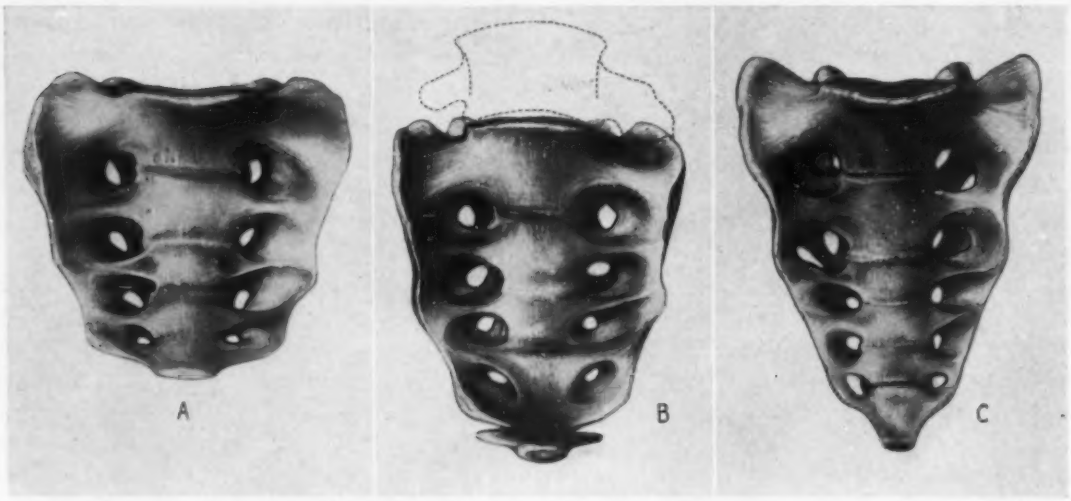

Fig. 16.* Variations in the sacrum (front view). *A*, short broad female type five segments; *B*, partial fusion of 5th lumbar vertebra and first coccygeal vertebra; *C*, complete fusion of either coccygeal or 5th lumbar vertebra to form a sacrum with six segments.

* Courtesy of *Am. J. Obst. & Gynec.*

result of these variables, the presence of a narrow arch is no reliable index to the width of the fore pelvis. This particular point is described to advantage in the two case studies illustrated in Figure 14. Both pelves have equally narrow arches as viewed from the front. In one case, which is a characteristic android, the intertuberous and interspinous diameters are both wide. The side walls of the pelvis are straight. Convergence is present only in front of the intertuberous diameter where the pubic and ischial rami conform to the narrow subpubic arch. As a result a well-formed pelvis was maintained from inlet to outlet in spite of the narrow subpubic arch (Fig. 14, *A* and *C*). A spontaneous delivery of an average-sized child occurred. In the other case (Fig. 14, *B* and *D*) the side walls began to converge rapidly from the inlet toward the interspinous and intertuberous diameters and effected a definite narrowing in each. The general pelvic shape conformed to the android-anthropoid type, which is radically different from the pelvis associated with the narrow subpubic arch shown in Figure 14, *A* and *C*. In this case, arrest in the occipitoposterior position occurred with a small child, and a medium forceps operation was necessary to effect delivery. Thus a narrow subpubic arch by itself may fail to indicate the anatomical pelvic type upon which the mechanism of labor depends. The term "funnel" is therefore too indefinite to have a place by itself in a classification of pelvic types.

The Ischial Spines. Ischial spines in shape may be sharp, average, or blunt (Fig. 15). The length of the spines is also variable. In certain anthropoid types no appreciable elevation from the flat surface of the ischium can be noted. In other pelves the spines may consist of long bony spurs projecting inward from the lateral walls of the pelvis. The interspinous diameter is almost invariably smaller than the intertuberous and the widest transverse diameter of the inlet. For the most part, the presence or absence of convergence of the side walls is the factor which determines the palpability and obstetrical significance of these landmarks (Fig. 13). These variations in the ischial spines may or may not effect a decrease in the interspinous diameter. The narrow interspinous diameter by itself is, however, no more significant an index to outlet capacity than the narrow subpubic arch. Long sharp spines may

occur in a normal pelvis and reduce the interspinous diameter to an appreciable degree. This diameter may be reduced to a similar degree in another type of pelvis and lead to more serious obstetrical difficulty. In both, of course, the mechanism of labor may be modified by it, but in the normal pelvis there is compensatory space in front of or behind the interspinous diameter which the head may follow or be made to follow by a simple manual maneuver. In more abnormal pelves, however, where less space exists in front or behind, as in the android type, the shape of the pelvis may tend to hold the head in the plane of the narrow interspinous diameter and lead to a serious form of arrest. It has long been known that the narrow interspinous diameter may interfere with the rotation of the head in the occipitoposterior position. The degree of ease or difficulty encountered in anterior rotation of the head is due, not to the narrow diameter as much as to the pelvic shape in front of and behind the biischial plane. Thus, no single diameter by itself should be used as a "rule of thumb" to represent the index of pelvic size to compare with head volume.

The Sacrum. The examination of separate sacrums will reveal great diversity in length, width, and number of segments (Fig. 16). The sacrum shows two forms of curvature around its longitudinal axis, the transverse and anteroposterior types. The transverse concavity can be seen through the pelvic inlet in the articulated pelvis (Fig. 17). As a rule, the anterior margin of the sacrum is straight transversely and helps to maintain an occipitotransverse position, especially in android types (Fig. 17, *A*). The sacral alae may protrude in front of the promontory and cause a deep transverse concavity in the sacrum (Fig. 17, *B*). This type of concavity is found frequently in anthropoid types and may add appreciably to the anteroposterior length and assist in causing an occipitoposterior position. Variations in the anteroposterior curvature in the longitudinal axis of the sacrum can be seen to advantage from the lateral aspect when the average, straight, and markedly concave types are noted (Fig. 18, *A*, *B* and *C*).

The degree of sacral inclination is shown by the size of the angle subtended by the plane of the inlet and the anterior surface of the upper sacral segments (Fig. 1, *B*). A study of the lateral roentgenograms illustrated in Figure 18 will reveal, in addition to the various types of curvature, examples

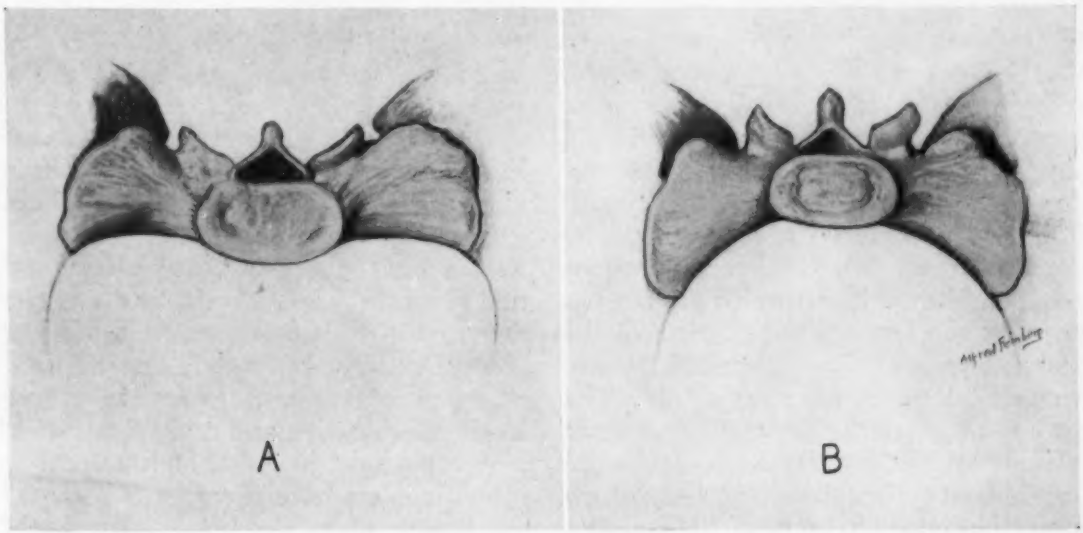

Fig. 17. Transverse sacral concavity. *A*, straight margin to first sacral segment, common in android types; *B*, markedly concave margin of first sacral segment, common in anthropoid types.

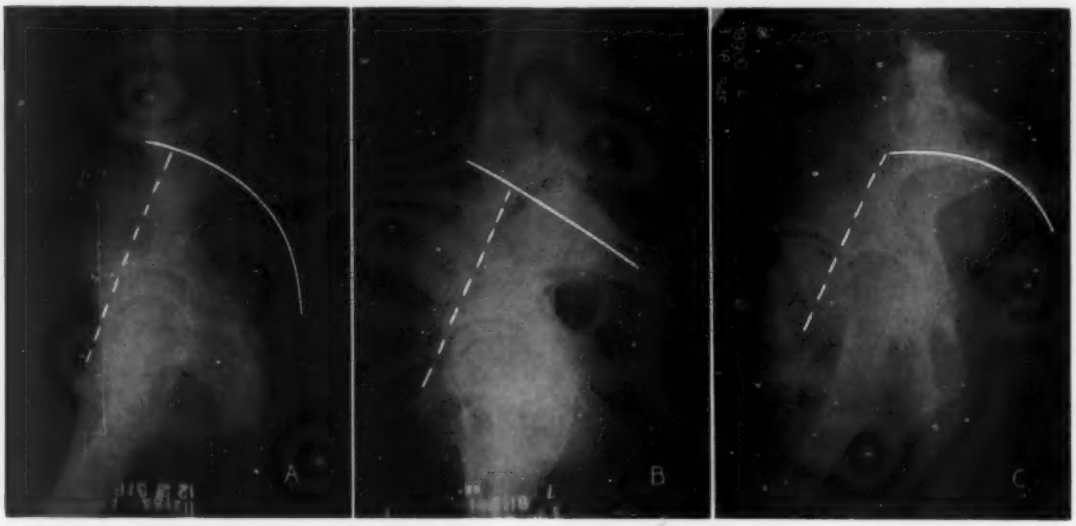

Fig. 18. Variations in sacral curvature (lateral view), inclination, and posterior pelvic capacity.

A, average curvature and forward inclination to the sacrum. Convergent bore from the lateral aspect. Note the length of the posterior sagittal diameter at the level of the spines and the level of the sacrococcygeal platform below. The head was arrested in the occipito-anterior position by the forward sacrum at a low level over the pelvic outlet.

B, straight curvature and average inclination to the sacrum. Note the ample posterior sagittal diameter at the level of the ischial spines. Straight bore from the lateral aspect. The straight sacrum carries the sacral tip and the sacrococcygeal platform to a low level. As a result the head descended to a low level to become arrested in the occipitotransverse position due to a flat android type of inlet (lateral view of Fig. 5, Part III).

C, marked curvature and backward inclination to the sacrum. Divergent bore from the lateral aspect. Note ample posterior sagittal diameter at the level of the spines to be utilized by the head if the inlet is ample enough to allow descent. Delivery by caesarean section. Android-flat type of inlet. Absolute obstruction at the inlet. Films obtained in labor show cone-shaped moulding of the head to the short anteroposterior diameter at the inlet.

of forward (less than 90°), average (90°), and backward inclinations (greater than 90°). The bore of the pelvis as viewed from the lateral aspect is formed by the slope of the posterior aspects of the symphysis and pubic rami in front and the anterior surface of the sacrum behind. Convergent, straight, and divergent types may be recognized (Fig. 18). Common variations in the lengths of the posterior sagittal diameter at the level of the spines and the distance between this plane and the sacrococcygeal platform are also shown. The length of the posterior sagittal diameter at the inlet and at the level of the ischial spines indicates the existing capacity which allows the head to *descend through the posterior pelvis*. The level of the sacrococcygeal platform and forward or backward position of the sacral tip indicates *how low* the head will descend, provided, of course, the head is guided by the soft parts through the posterior segment.

It is evident that the variations in sacral inclination and curvature just described along with the character of the ischial spines and the variable degrees of convergence of the side walls can cause marked differences in the shape of the outlet. These departures from the normal in the lower pelvis should be carefully described by the roentgenologist in each individual case. Their classification and relationship to the inlet type, however, is difficult unless some attempt is made to describe the shape of the bony outlet. The pelvis illustrated in Figure 19 is wide at the inlet, and interspinous and intertuberous diameters are

wide, and the sacrum flares backward. By convergence of the side walls or variations in sacral curvature and inclination, the shape of the pelvis below the level of the ischial spines *in front of the sacral tip* may change and conform to the *long oval, the round, the flat, or wedge-shaped type.*

Pelvic Depth. The length of a perpendicular line extending from the tuberosity of the ischium to the plane of the inlet represents the best index of the depth of the true pelvis (Fig. 1, *C*). Schuman[14] has recently reported a clinical means of determining this length. We measured this diameter in a number of Todd's skeletal pelves and noted that for females the average depth was 8.5 cm. and for males 10 cm. In approximately 6 per cent of the cases, female pelves approached the average depth of the male pelvis. The practical significance of increased pelvis depth is obvious. In large pelves an increase in depth of 1 to 2 cm. causes no appreciable effect upon the mechanism of labor. However, if the pelvis conforms to characteristic android, anthropoid, flat or small gynecoid types, increased depth to the pelvic cavity becomes important and may cause delay in anterior rotation or low arrest of the fetal head.

4. Frequency of Occurrence of Pelvic Types

The frequency of occurrence of these anatomical forms on the basis of the four parent types appears to vary according to

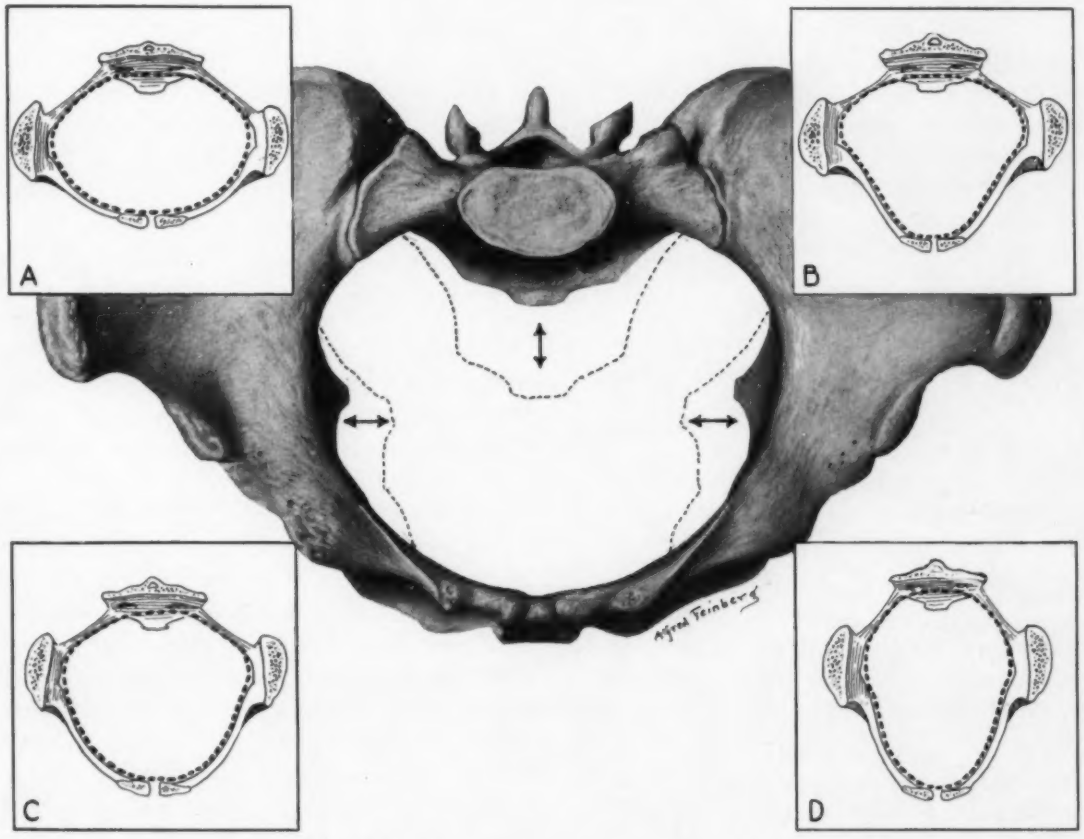

Fig. 19.* Variations in the shape of the lower pelvis as caused by variations in the splay of the side walls laterally and the inclination and curvature of the sacrum in the sagittal plane. *A*, the flat type or transverse oval; *B*, the wedge-shaped type; *C*, the round type; *D*, long narrow oval type.

* Courtesy of Thomas Nelson & Sons.

race and constitutional peculiarities within the race. The racial influence is revealed in the accompanying table based on a classification of the pelves at Western University (Table III). The anthropoid type is more frequently encountered in the black race, while the android type is more prevalent in the white race. The platypelloid type is rare for both races but is more often seen in whites than blacks. If the borderline flat pelves are included, the incidence of the platypelloid type is increased.

Table III

	Western Reserve Material*		Sloane Hospital for Women	Pettit, Garland, Dunn, Shumaker†
	Female White	Female Negro	Mixed Race	
Anthropoid type	23.5%	40.5%	22.7%	18.0%
Gynecoid type	41.4%	42.1%	50.6%	51.0%
Platypelloid type	2.6%	1.7%	4.4%	5.0%
Android type	32.5%	15.7%	22.4%	21.0%
Asymmetrical	—	—	1.8%	5.0%

* Number of cases female white—147. Number of cases female negro—121.
† Recent article by these authors.[12]

We have determined the frequency of occurrence of pelvic types in a consecutive series of 215 obstetrical patients at the Sloane Hospital for Women. The results showed, as one would expect, a greater incidence of gynecoid and large ample android and anthropoid types with fewer of the anatomically characteristic android, anthropoid, and platypelloid types which were so numerous in Todd's material. It is obvious that types of individuals whose skeletal remains are found in museum collections cannot be compared with a series of normal young female adults all of whom are pregnant. Naturally, in such a normal series, the structural form ought to be more characteristically female than in Todd's collection of skeletal material. Pettit, Garland, Dunn, and Shumaker[12] have determined the frequency of occurrence of pelvic types according to this classification and their results are very similar to our own.

Table IV

Pelvic Type	No. of Cases	Conjugate Diameter cm.	Transverse Diameter cm.
White Stock			
Gynecoid	26	10.8	13.7
Android	25	10.5	13.5
Anthropoid	19	11.7	12.9
Platypelloid	3	8.5	14.4
Mixed average for females	73	10.9	13.5
Average for males	43	10.1	13.0
Negro Stock			
Gynecoid	34	10.5	12.9
Android	11	10.4	12.6
Platypelloid	2	9.1	13.6
Mixed average for females	90	11.0	12.5
Average for males	52	9.8	11.6

5. Average Measurements

We are greatly indebted to Professor T. Wingate Todd of Western Reserve University, Cleveland, for his interest and cooperation in the study of pelvic morphology and for permission to use the following measurements obtained by him directly from the wet torso before maceration. These measurements, arranged below in Table IV, become especially valuable from the obstetrical standpoint when it is realized that they closely approach the actual measurements of the living state. The pelves from which these measurements were obtained were arranged by us accord-

ing to the classification just described and all intermediate types were placed in the nearest related parent or primary group.

The average measurements in female pelves for each of the four groups compare with the expected average when the classic shape of each group is recalled. This table also includes average inlet measurements from 95 male pelves, 43 of white and 52 of negro stock. It is interesting to observe that the male inlet, even from measurements alone, is not characteristically a long oval or anthropoid type. The transverse diameter is longer than the anteroposterior diameter, although the ratio between the two diameters is greater in the white than in the negro race. Emphasis is placed upon this observation because in Table II we have mentioned that a study of a small series of casts of the male inlet prepared by Professor Todd led us to believe that the characteristic appearance of the male inlet was wedge shaped rather than a long oval. This fact has been considered in our suggesting the term "android," to designate a wedge-shaped inlet for both sexes.

SUMMARY OF CLASSIFICATION AND DESCRIPTION OF THE PELVIS

Measurements of common pelvic diameters recorded as obtained by methods of roentgen pelvimetry

I. The anthropoid type (pure or parent type)—large, average, or small
II. Intermediate or mixed types between the anthropoid and gynecoid types—large, average or small
   (a) anthropoid-gynecoid type*
III. The gynecoid type (pure or parent type)—large, average, or small
IV. Intermediate or mixed types between the gynecoid and platypelloid (flat) types—large, average or small
   (a) gynecoid-flat type
V. The platypelloid type (pure or parent type)—large, average, or small
VI. The android type (pure or parent type)—large, average, or small
VII. Intermediate or mixed android types—large, average, or small
   (a) android-anthropoid type
   (b) android-gynecoid type
   (c) android-flat type
VIII. Asymmetrical pelves
IX. The pathological pelvis—rickets, osteomalacia, congenital anomalies, and deformities due to sacroiliac and spinal disease, etc.

In each individual pelvis, the following regions of the lower pelvis must be described in detail:

(a) Subpubic arch—wide, moderate, narrow
(b) Pubic rami—straight or curved
(c) Splay of side walls—divergent, straight or convergent
(d) Is the fore pelvis well formed or funnel shaped?
(e) Character of the ischial spines
(f) The sacrosciatic notch—wide, average, or narrow masculine type
(g) The sacrum—a general concept of length, width, curvature and number of segments
(h) Sacral inclination—forward, average, backward
(i) Lateral bore—straight, convergent or divergent
(j) Posterior pelvic capacity at the inlet and at the level of the spines and the relationship of the sacrococcygeal platform to the latter
(k) Shape of the outlet in front of the sacral tip

Finally, the pelvis should be studied as a whole to determine whether it is well formed or angular, irrespective of the gynecoid, android, anthropoid, or flat character of the pelvic inlet.

* The four parent types and the five mixed forms most frequently encountered are shown in Figure 9. We originally described three borderline types between the anthropoid and gynecoid parent forms, i.e., the anthropoid-gynecoid, the gynecoid-anthropoid, and the gynecoid type with a narrow fore pelvis. For the sake of simplicity, we prefer to consider all such minor variations as anthropoid-gynecoid types.

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THE COMPARATIVE VALUE OF RADIOPAQUE SUBSTANCES USED IN UTEROSALPINGOGRAPHY*†

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IN THE course of experiments upon the rhesus monkey involving problems of tubal and uterine physiology, we had occasion to use radiopaque substances the value of which, it seemed to us, proved of sufficient interest to warrant recording.

This report is intended only as a brief comparison between those radiopaque substances which have been used clinically or which might be employed by others in the human female. Although the number of animals in which the observations were made is small, the data obtained seem of significance. Our purpose is rather to indicate a method of estimating the value of these radiopaque substances in an animal most resembling the human female in structure and function, and, furthermore, to stimulate work by investigators who have the interest, time and facilities to pursue it.

The radiopaque fluids were, in the main, injected into the uterus under manometric control, the pressure being provided by CO_2 gas delivered from a tank under 1,000 lb. pressure reduced by a regulating valve to 15 lb. pressure and measured by a syphon meter conveniently assembled in the Rubin tubal insufflation apparatus. The pressures were recorded on a revolving drum. In practically all the animals a preliminary gas insufflation was done to demonstrate the amount of pressure necessary to cause the gas to pass through the tubes, and also for the specific purpose of comparing differences of pressures when the fluid was injected. These comparative pressure findings will not be considered here. Only in one instance was the fluid injected by a syringe without manometric control, the pressure data having been obtained by a preliminary gas insufflation.

Roentgenoscopic visualization in the monkey is extremely satisfactory because the abdominal wall is relatively thin. The fluid was injected through a uterine cannula which was held tightly within the cervical canal to prevent regurgitation. It may be noted here that the cervix was first split in order to circumvent the colliculus which would otherwise prevent the introduction of the cannula.

The data obtained from the use of these radiopaque substances were considered from two viewpoints: (1) their comparative shadowgraphic and diagnostic value and (2) the likelihood of retention residue. Several monkeys were subjected to the experiments and in some more than one radiopaque solution was injected at intervals. When the latter procedure was followed, preliminary films were taken before the subsequent injections to insure that the pelvis contained no residue of any previous solution employed. The solutions used included diodrast, hippuran, skiodan with acacia, umbrathor, iodochlorol and lipiodol. With the exception of umbrathor all these opaque media have been employed in clinical uterosalpingography, lipiodol being the most popular. We have found that lipiodol, iodochlorol and umbrathor in the concentration commonly employed, produced the densest shadows, skiodan with acacia produced the faintest, and hippuran and diodrast produced moderately good shadows.

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Fig. 1. Diodrast. Roentgenogram of uterine cavity. Tubal outlines not definitely made out.

Retention of radiopaque substances was most marked when umbrathor and lipiodol were used; least marked when iodochlorol was used and absent when skiodan-acacia, hippuran and diodrast were used.

Tubal patency was demonstrable by all of these opaque media. However, occasionally with umbrathor and lipiodol one tube only was visualized; no outline of the other was visible. With the exception of skiodan, hippuran, diodrast and umbrathor, the tube lumen was demonstrable in every case where the fluid passed into the peritoneal cavity. Skiodan with acacia passed so rapidly through the tubes that their lumina were not distinctly differentiated from the spill into the peritoneal cavity which overshadowed the region of the tubes themselves. Hippuran and diodrast, also employed as skiodan with acacia in the concentrations for urographic purposes, passed through the tubes with equal rapidity, so that the tubal lumina were not invariably differentiated from the spill into the peritoneal cavity. This appears to be due to the aqueous solution in contrast with the oily organic combinations of iodine.

When umbrathor or lipiodol was used, residual shadows of the opaque media were observed for days and weeks. Iodochlorol disappeared from the peritoneal cavity with much greater rapidity than lipiodol. The crystalloid roentgenographic substances, namely, diodrast and hippuran, were absorbed within a half hour to several hours at the most. In a few instances where umbrathor and lipiodol were used, it appeared as though there was inspissation in the tube which prevented the passage of the less viscous media such as skiodan, hippuran and diodrast. Whether this was due to inspissation or to a foreign body reaction was not determined as no histologic examinations were made.

The notes on the first experiment will serve to describe the method as used. The cannula, as employed for uterotubal insufflation, described by Morse and Rubin,[1] was introduced into the uterus. A tubular glass container tapering at both ends and containing 35 per cent diodrast solution was connected by rubber tubing and the tubing temporarily clamped. The lower end of the glass container was held at a level of the monkey's symphysis. The upper end was attached to the rubber tubing of the insufflation apparatus. The pressure of gas was raised to 200 mm. Hg, at which point a roentgenoscopic examination was made which showed that some of the solution had passed into the uterine cavity. Four films were taken. A roentgenogram of the uterine cavity is shown (Fig. 1), but the tubal outlines are not yet definitely made out. At 220 mm. Hg, the diodrast began to pass through the tubes. Figure 2 shows a spill into the left side of the pelvis; none on the right side. The outline of the left tube was only partially differentiated; the right tube could not be identified. The solution was then aspirated from the uterine cavity and CO_2 gas was allowed to pass into it. Figure

[1] Morse, A. H., and Rubin, I. C. Uterotubal insufflation in the *Macacus rhesus;* method of assaying pharmacologic and hormonal effects on tubal and uterine contractions; preliminary report. *Am. J. Obst. & Gynec.*, 1937, *33*, 1087–1092.

Fig. 2. Diodrast. Spill of diodrast into left side of pelvis; none on right side. Outline of left tube only partially differentiated. Right tube cannot be identified.

Fig. 3. Diodrast. Well defined outline of uterine cavity following withdrawal of solution.

Fig. 4. Hippuran. The ampulla of the right tube is dilated; the left tube is not distinctly outlined.

Fig. 5. Hippuran. Uterine cavity following withdrawal of solution.

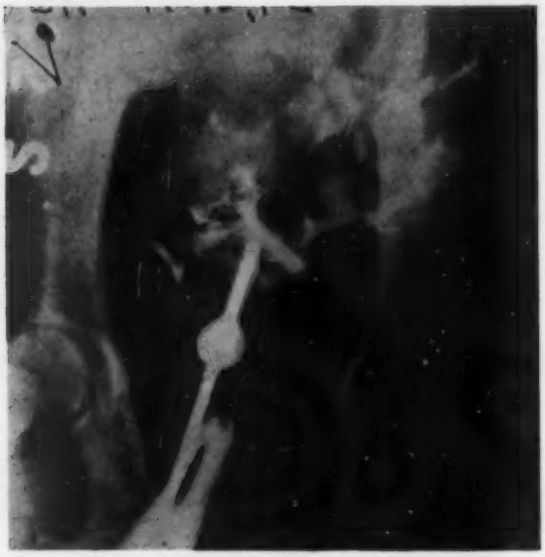

Fig. 6. Skiodan-acacia. Spill of solution through tubes into peritoneal cavity. Some of the fluid extends up to the crest of the ilium.

3 shows a well defined outline of the uterine cavity. Later films showed a definite shadow of diodrast in the pelvic cavity more marked on the right side than on the left. A film taken fifteen hours after the termination of the experiment showed nothing characteristic in the peritoneal cavity to distinguish shadows from intestinal contents.

In this connection it may be noted that in previous experiments we have found an unequal patency of the tubes. For example, with the cannula in the uterus, the abdominal cavity open and the pelvic cavity filled with salt solution, we have seen gas bubbles arising at the end of the right tube and none from the vicinity of the left—or, on the other hand, we have noted a much freer flow of gas through one tube than through the other.

Failure to visualize one tube does not necessarily mean tubal closure at the uterine end. The apparent tubal closure may be due to increased tonicity as compared to the tube of the opposite side which permits the opaque fluid to pass through. The relatively patent tube may be at another time the spastic tube. This is a point requiring further observation before it can be elucidated. It does not matter what fluid is employed. Curiously enough, the same condition obtains when CO_2 is insufflated, the least resistant tube allowing the gas to pass through its lumen.

Hippuran was employed in two instances. Films taken following the introduction of the solution showed the ampulla of the right tube (Fig. 4), but the left tube was not distinctly outlined. Figure 5 showed a fair aerogram of the uterine cavity following the evacuation of the radiopaque solution. The question arises whether the relatively poor results with hippuran may not have been due to the weakly concentrated aqueous solution which was employed.

Skiodan 40 per cent with acacia 20 per cent in distilled water was injected into the uterus of animal No. 402. The first four films (Fig. 6) showed a spill through the tubes into the pelvic cavity, some of the fluid extending up to the crest of the ilium. It was impossible to distinguish the uterus *per se*. There was no clear cut definition of the uterus or of the tubes, possibly because there was rapid absorption or wide diffu-

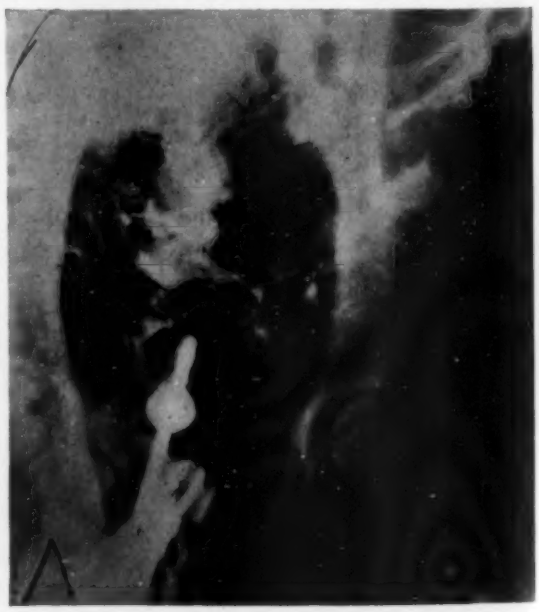

Fig. 7. Skiodan-acacia. Notable spill into pelvic cavity. No definition of uterus or tubes.

Fig. 8. Umbrathor. Roentgenogram of uterus with crenated borders. Left tube visualized; right not seen.

Fig. 10. Umbrathor. Pelvic spill which masks both tubal outlines.

sion of the solution (Fig. 7). The shadows in the pelvis were of about the same density as bone. A film taken three days after the experiment showed no residue of the solution in the pelvic cavity.

Fig. 9. Umbrathor. Small scattered area of residue on left side of pelvis forty-seven days after injection.

Fig. 11. Umbrathor. At the right uterine horn a transverse partition is visible beyond which a bubble of gas extends to the uterotubal junction.

Fig. 12. Umbrathor. Residue remaining in pelvis forty-seven days after injection.

Fig. 13. Umbrathor. Residue remaining in pelvis thirty-three days after injection.

In animal No. 389, umbrathor was injected under a pressure of 220 mm. Hg. The left tube was visualized by a moderately intense shadow; the right was not seen (Fig. 8). There was no spill into the peritoneal cavity. Residue was seen six days after the original introduction of the solution and could not be distinguished from the possible presence of umbrathor within the tube lumen. At the end of forty-seven days in animal No. 389 there remained a small scattered area of umbrathor on the left side (Fig. 9). Umbrathor was similarly injected

Fig. 14. Umbrathor. Salpingogram with area of contraction at infundibulo-ampullary junction. Tubes previously ligated.

into animal No. 390. Figure 10 shows a pelvic spill of the solution which masks both tubal outlines. Figure 11, a film made after the injection of CO_2 into the uterus emptied of umbrathor, shows in the right uterine horn a transverse partition beyond which a bubble of gas extends to the uterotubal junction. The pelvis of this animal also showed a considerable residue of umbrathor at the end of forty-seven days (Fig. 12). Another animal similarly injected with umbrathor showed a residue in the pelvis after thirty-three days (Fig. 13).

Fig. 15. Umbrathor. Showing different phases of the constriction at the infundibulo-ampullary junction.

Fig. 16. Umbrathor. Showing possible constriction at the isthmus uteri.

Fig. 17. Iodochlorol. Both tubes outlined; the right more clearly shown than the left.

Fig. 18. Iodochlorol. Irregular tubal outlines suggesting a writhing action due to tubal contractions.

Fig. 19. Iodochlorol. Escape of solution into the pelvic cavity obscuring outline due to pelvic spill.

Fig. 20. Iodochlorol. Shows diffusion of globules of solution. Outline of uterine mucosa bathed with iodochlorol.

The fimbriated end of both tubes of animal No. 278 was ligated with fine black silk and five days later umbrathor was introduced into the uterine cavity with a syringe. Figure 14 shows a well defined salpingogram with a beautiful area of contraction at the infundibulo-ampullary junction. The left tube shows a faint shadow in contrast to the right. Figure 15 shows different phases of the constriction at the infundibulo-ampullary junction. Upon removal of the cannula the uterus was found still filled with umbrathor, suggesting the possibility of a constriction at the isthmus

Fig. 21. Iodochlorol. Residue of iodochlorol in pelvic cavity twenty-four hours after injection.

uteri (Fig. 16). Following the release of the uterus from the bullet forceps grasping the cervix, the uterus resumed its normal elevated position and the tubes were found now to occupy a different position.

Iodochlorol was injected into the uterine cavity of animal No. 390 under a pressure of 160 mm. Hg. Figure 17 shows both tubes outlined, the right being more definitely shown than the left. Figure 18 shows an irregular outline of the tubes suggesting a

Fig. 22. Iodochlorol. Residue of iodochlorol in pelvic cavity seven days after injection.

Fig. 23. Lipiodol. Silhouette of uterine cavity. Left tube outlined; right not visible.

Fig. 24. Lipiodol. Distribution of lipiodol in pelvic cavity.

Fig. 25. Lipiodol. Residue of lipiodol in pelvis twenty-four hours after injection.

writhing action due to tubal contractions. Figure 19 shows an escape of the solution into the pelvic cavity with an obscuring of the tubal outlines due to the pelvic spill. Figure 20 shows a diffusion of globules and

an outline of the mucosa bathed in iodochlorol. Figures 21 and 22 show the residue of iodochlorol twenty-four hours and seven days respectively following its injection.

Lipiodol was employed in animal No. 389. Figure 23 shows a silhouette of the uterine cavity and an outline of the left tube; the right tube was not shown. The shadow is extremely dense as compared with the bone. This was contrary to the findings when umbrathor and hippuran were used in this animal. Peristaltic gaps are also seen. The distribution of lipiodol upon removal of the cannula is shown in Figure 24. Twenty-four hours later a scattered lipiodol residue was found (Fig. 25).

The finding of gaps in the tubal lumen appeared to be peculiar to the use of lipiodol as it had not been observed when the other substances, except umbrathor, were used. Whether this is due to the oil viscosity or to some other property inherent in lipiodol cannot be answered at the present time.

In our rhesus monkeys the injection of radiopaque substances was not followed by obstructions in the tubes which prevented the occurrence of pregnancy. However, it is quite possible that inasmuch as one of the tubes did not appear in the roentgenogram it may well have been the one which eventually permitted the ovum to pass from the ovary of the corresponding side.

SUMMARY

In reviewing the results obtained with the injection of radiopaque substances into the uterus of the rhesus monkey, an estimate of their comparative value was based upon:

(a) The readiness with which the fluid passed into the tubes and out into the peritoneal cavity.

(b) The comparative density with the bony structure from which it could be differentiated.

(c) The resorption rate.

(d) The persistence of the residue.

(e) The obstructive tendency through inspissation.

1. The crystalline iodine compounds commonly employed in excretory urography (skiodan, hippuran, diodrast) when injected into the uterus of the *Macacus mulata* passed through the oviducts into the peritoneal cavity so rapidly that the tube outlines as such were overshadowed by the spill into the pelvis. Their resorption rate was very rapid. By comparison with bony density the uterotubal outlines produced by these substances were relatively faint but satisfactory.

2. Lipiodol gave excellent roentgenographic pictures in comparison with bone density which were superior to the aqueous solutions. It afforded the clearest shadows but showed residue for days. There appeared to be a retention of lipiodol within the tube and whether a hyperperistalsis may not have been induced by the presence of the radiopaque substances must remain open.

3. Umbrathor gave excellent roentgenograms. Its persistence for days and weeks is disadvantageous.

4. Iodochlorol yielded satisfactory roentgenograms and its resorption rate was considered to be more rapid than that of lipiodol.

5. Despite the repetition in the monkey of uterotubal insufflation with radiopaque substances there seems to have been little injury to the tubal mucosa since two of our animals became pregnant shortly after the termination of our experiments. Whether the fertilized ovum was conveyed by the tube not traversed by the opaque solution is a matter of conjecture.

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LATE EXTRAUTERINE PREGNANCY DIAGNOSED BY SOFT TISSUE ROENTGENOGRAPHY

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IN THE past five years there were 3 cases of late extrauterine pregnancy with a live fetus roentgenographed at the Harlem and Bronx Hospitals. The first one was recognized clinically but not roentgenologically. The other two were not suspected clinically but were diagnosed from the study of the roentgenograms alone. Though this condition is infrequent it was recognized because we have been interested in the roentgenography of the soft structures of pregnancy.

Moloy and Swenson[1] mention a case which was recognized clinically and showed a high asymmetrical disposition of the fetus on roentgen study. They infer that the roentgen evidence was insufficient. Taussig,[2] in a discussion of Matthew's paper on the roentgen ray in obstetrics in 1930, mentions 2 cases of abdominal pregnancy at Barnes Hospital, St. Louis. The roentgenograms showed a small uterus in the pelvis with the full term fetus lying outside the limits of this uterine shadow. He felt convinced that in a third case of this kind he would be able to make the diagnosis from roentgen examination alone. As will be seen from the material presented here, it is more than likely that what he considered to be uterus was uterus and placenta together.

In the earlier studies of the placenta by roentgen examination it was found that the uterine wall could be seen enveloping the fetus.[3] It usually measures from 1 to 1.5 cm. in thickness when the film-target distance is 30 inches. The lack of the shadow of the uterine wall over the fetus gave the proper clue to the 2 cases to be described.

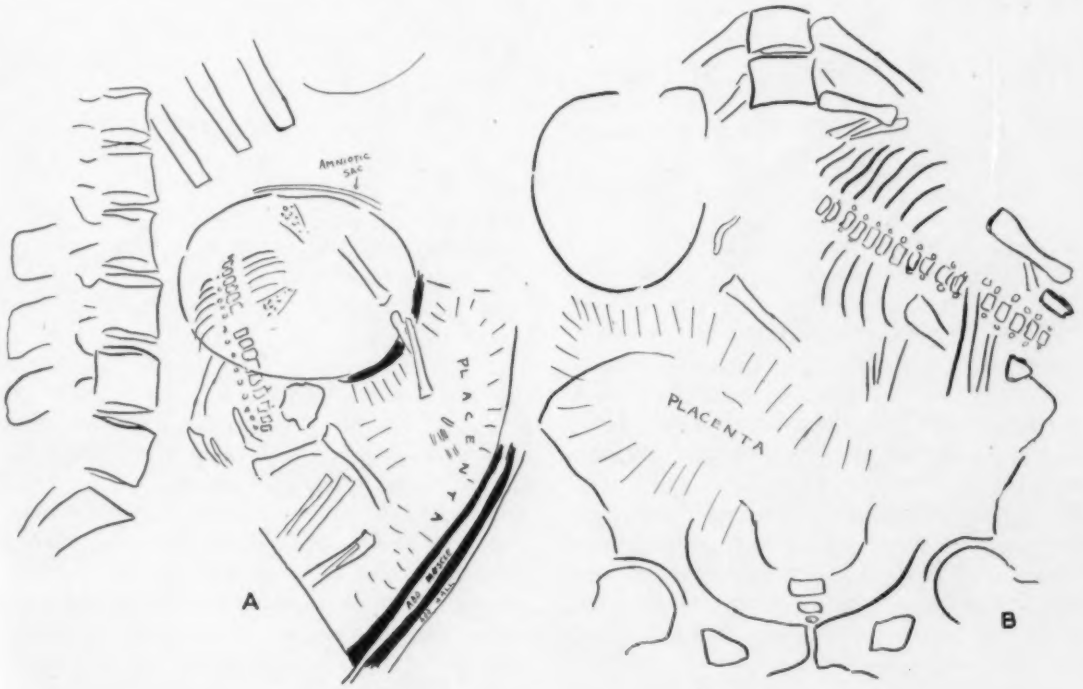

FIG. 1, *A* and *B*. Case 1.

CASE REPORTS

Case I (No. 4054). Patient was sent to the Bronx Hospital Roentgen Department for examination in the last month of her pregnancy. The diagnosis on the card was "possible hydramnios."

Roentgen study showed none of the findings of hydramnios, namely, geometric soft shadows surrounding the fetus. (A paper on this subject is in preparation.) The placenta was distinctly outlined in the left lower quadrant, and as usual, within it could be seen the pressure defects caused by the fetal extremities. The head was very high on the left and the buttocks low on the right. Over the head and adjacent parts of the thorax, the uterine wall was absent. From these findings a roentgen diagnosis of extrauterine pregnancy, near term, was made. Incidentally, the amniotic sac could be seen as a thin layer over the upper margin of the head. This we have never seen on roentgen examination of intrauterine pregnancy.

Dr. Irving Smiley, the attending obstetrician who was called to see the patient, found from the history that the patient had a slight menstrual flow when ten weeks pregnant. She had had episodes during which she developed secondary anemia. On admission to the hospital her hemoglobin was 40 per cent and she was in mild shock. At operation an abdominal pregnancy was found. The fetus was alive and the placenta was located in the left lower quadrant. It was already partly detached and was easily freed from the left adnexal region. The abdomen was full of large blood clots. The mother made a complete recovery. The child died after five hours.

The operative findings confirmed not only the roentgen findings of extrauterine pregnancy but also the location of the placenta.

Case II (No. 26,361). A patient was sent to the Harlem Hospital Roentgen Department for examination. The diagnosis on the request card was transverse presentation of fetus and possible placenta previa.

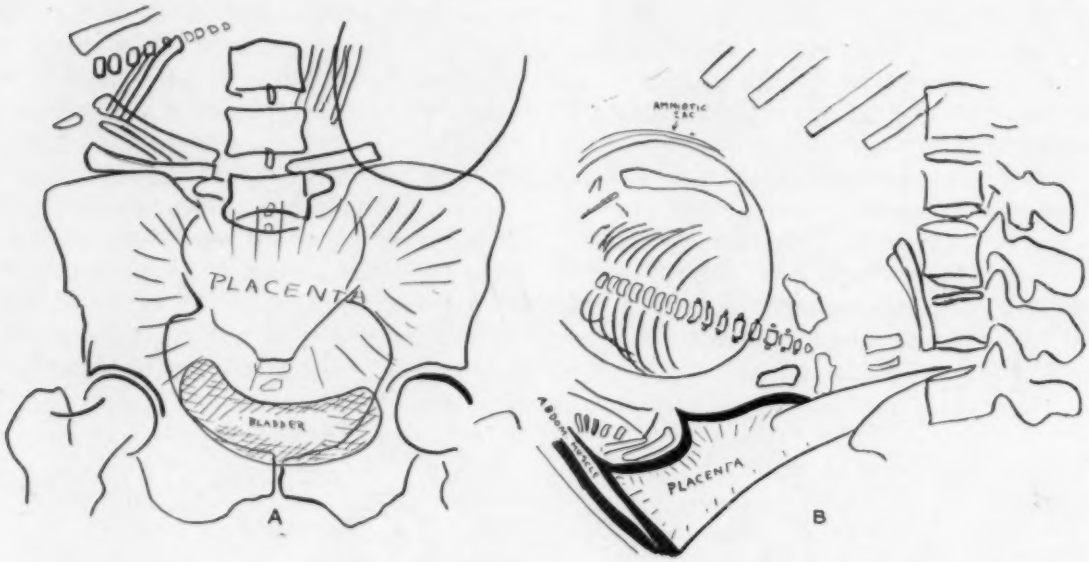

Fig. 2, *A* and *B*. Case II.

On roentgen examination, a fetus near term was found lying in transverse presentation, high in the abdomen, head to the left, dorsum cephalad, small parts caudad. Between the fetus and the urinary bladder which was filled with radiopaque fluid (after Ude, Weum and Urner[4]) and air, our own variation, a very large soft tissue shadow measuring about 15 cm. in diameter was outlined. This was interpreted as placenta because it showed pressure defects caused by the fetal extremities. It would seem then that the clinical diagnosis of placenta previa was correct, especially since the patient came to the hospital because she had lost per vaginam one and a half cups of blood. How-

ever, the uterine wall shadow was missing over the upper portion of the fetus. The diagnosis of extrauterine pregnancy at or near full term was made, and the placenta was placed low in the midline, a large part of it situated anteriorly. Incidentally, the urinary bladder showed an oval pressure defect on its upper border; this is the usual picture of pressure by the uterus when slightly enlarged. Over the upper part of the fetus could be seen the shadow of the amniotic sac as in the previous case.

Dr. Julius Kurzrock, the attending obstetrician, operated and removed an extrauterine live baby. The placenta was located over the fundus of the uterus.

In reviewing the history it was elicited that when there had been four months' amenorrhea, the patient had been seized with severe abdominal pains and vomiting. On examination at that time she was told that her uterus was not enlarged and that she was not pregnant. It was suspected that she might have an intestinal obstruction, but she recovered without operation.

In summary, the operative findings confirmed the roentgen findings of extrauterine pregnancy and the location of the placenta.

COMMENT

The two late extrauterine pregnancies are described here with the hope that such cases may be recognized in the future. They were recognized by roentgen study of the soft structures.

In addition, soft part studies of pregnancy have helped both in the recognition and location of the placenta, the uterine wall, the presence and degree of hydramnios, and even the amniotic sac. This has been done without the aid of contrast substances. The roentgen procedure necessitates an ordinary anteroposterior view, and a right and left lateral view. These new roentgen observations of the soft tissues of pregnancy and their clinical importance have been prepared for publication with Dr. Meyer Rosensohn.*

In a normal case, on roentgen examination the uterine wall, as stated before, is seen to completely surround the fetus. In most cases its actual thickness can be noted, particularly opposite the placenta. The latter occupies about one-third the surface of the uterine wall, the shadows of both appearing as one where they meet. The small parts of the fetus almost invariably face the placenta, and where they come in contact, the placenta, being very soft, gives, showing pressure defects. The subcutaneous fat of the fetus can easily be seen at these points and serves to demarcate the placenta from the fetal parts. Even moderate increases in amniotic fluid can be detected. If hydramnios is present, its shadow runs together with that of the placenta. It then appears as if the placenta were completely surrounding the fetus. Since this is extremely unlikely, the diagnosis of hydramnios may be made. This can be visualized best in films of pregnancy complicated by monstrosities.

Another observation which was shown by the second case was the occurrence of a pressure defect on the upper wall of the urinary bladder by the uterus which was smaller than it should have been for the period of gestation. From such studies, it is possible to tell whether the uterus is only slightly increased in size or sufficiently enlarged as to contain a full term fetus.

In extrauterine pregnancy it is probable that the placenta will be located somewhere between the fetus and the urinary bladder. It is therefore likely that by roentgen examination this condition may have to be differentiated from placenta previa. In that connection the shape of the pressure defect on the urinary bladder, as above described, might help; but, above all, the absence of the uterine wall over the fetus is a very valuable aid in the differential diagnosis.

SUMMARY

1. Two cases of late extrauterine pregnancy were recognized by roentgen examination.

2. The diagnosis led to successful treatment of the patients.

3. Though this condition is uncommon, the diagnosis was based on a knowledge

* To be published in a subsequent number of this Journal.

of the soft parts as revealed by roentgen study, the understanding of which may have a more universal application.

4. We have thus far been able to show the placenta, uterine wall, amniotic fluid and even the amniotic sac by roentgen study. The lack of uterine wall over the fetus was an important clue in the two cases described.

5. With the aid of contrast substance in the urinary bladder, we have been able to infer that the pressure on it by the uterus indicated that the latter was only slightly enlarged and therefore too small to hold the outlined fetus.

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ROENTGEN PELVIMETRY

A SIMPLIFIED PARALLAX METHOD*

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MANY methods of pelvimetry by roentgenographic means have been presented as an aid to the obstetrician, but none have found wide use due to the necessity of special equipment required for accuracy. Simpler methods, as pointed out by Hodges and Ledoux, possess inherent possibilities of gross error. In the same paper, these workers described a procedure, using special precision apparatus, designed for academic rather than clinical purposes. It is our purpose to emphasize the simplicity, accuracy, and practicability of their procedure, even when equipment now in the possession of all progressive hospitals and roentgenologists is used.

During the past two years, the stereoscopic method described by Moloy has been used in the Obstetrical Division of Bellevue Hospital. In addition to the cost and cumbersomeness of this equipment, it has been found that the degree of ocular skill and coördination required in its use is beyond the power of many who attempt it. It is not unusual to find discrepancies of definitely clinical importance in the figures obtained from the same set of films by different, presumably competent, operators. The Walton method, which the senior writer employs, while fairly accurate, entails considerable attention to the position of the patient and measurements of the distance of the superior strait of the pelvis to the film. The latter procedure in obese patients, or for that matter, in any pregnant woman, is subject to a reasonable margin of error. It was on this account that a more accurate method was sought.

THEORY: GEOMETRY OF PARALLAX MENSURATION

It is well to review the geometric basis of parallax mensuration. In the diagram (Fig. 1), T_1 and T_2 represent two positions of the target and F_1 and F_2 their respective projections upon the film. The target is shifted in a line parallel to the film, therefore T_1T_2 is parallel to F_1F_2. The line AB represents any diameter to be measured, lying in an unknown position in space, between the target and the film. The line

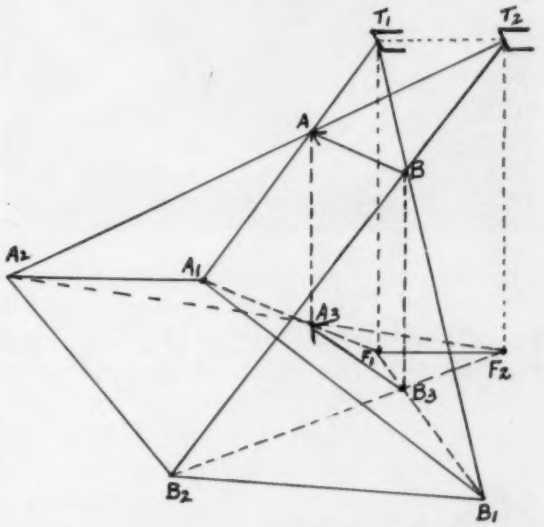

FIG. 1. Geometry of parallax mensuration.

T_1A_1 represents the ray passing from the target during the first exposure, obstructed by the point A. Similarly, the line T_2A_2 represents the ray obstructed by the same point during the second exposure. Since the triangles $T_1F_1A_1$ and $T_2F_2A_2$ are right triangles at the points F_1 and F_2 respectively, the lines A_1F_1 and A_2F_2 represent the projections of the respective rays, and, more specifically, the point A_3 represents the projection of their intersection A. In like manner, B_3, the projection of the intersection B, is determined. The line A_3B_3 is thus the projection of the diameter to be measured.

Since AB is the hypotenuse of a right

* Preliminary report. From the Roentgen-Ray Department of Bellevue Hospital.

Fig. 2. Appearance of superimposed films.

triangle whose sides are its projection and the difference in altitude of its extremities, it can be measured if the lengths of these altitudes, AA_3 and BB_3, are known. By similar triangles it can be shown that $AA_3=(T_2F_2)(A_1A_2)/A_1A_2+F_1F_2$, and that $BB_3=(T_2F_2)(B_1B_2)/B_1B_2+F_1F_2$. (These latter formulae are familiar to everyone who has been interested in localization technique. The general formula is expressed as: $\frac{\text{Distance}\times\text{Spread}}{\text{Spread}+\text{Shift}}$.) In the special case where the spread of the images of the extremities of AB, A_1A_2 and B_1B_2, are equal, it can be seen that the altitudes will be equal and $AB=A_3B_3$. This obviates the necessity for computing the altitudes when the spread of the images are equal, i.e., when the plane of the diameter to be measured happens to be parallel to the film. Furthermore, when the images of either extremity lie too close to the line of the footpoints, making localization of the projection impossible by construction, the distance of the projecting point from one of the footpoints may be computed algebraically. In practice, however, this computation is avoided simply by placing the midline of the patient more than 3 cm. from the midline of the film, along which lie the target footpoints (Fig. 2). This has special application in the measurement of the anteroposterior diameter.

From the foregoing, it is evident that the accuracy of pelvimetry, based upon these principles, is dependent only upon apparatus in which the target may be shifted a known distance, parallel to the film at a known distance from it, and upon accurate localization of the target footpoints on the film. The target footpoints are simply plotted upon the surfaces of two casettes, which are then marked by placing small lead shots, and fixed with adhesive plaster.

TECHNIQUE

The technique consists of making stereoscopic exposures of the pelvis, using the target footpoints, one of which lies in the exact center of the film, to determine the position of the target. Our practice was to use a 25 inch tube distance and 6 cm. tube shift, the latter parallel to the midline of the patient which, as noted above, is placed more than 3 cm. from that of the casette. In most cases, with the patient supine the various transverse diameters will lie parallel to the film, although no special effort need be made to accomplish this, since the measurement is in no way dependent upon position.

(*a*) The films thus obtained are placed in a stereoscope, the significant landmarks identified and marked on both films with a fine pointed pencil.

(*b*) Superimpose films using the target footpoints as a guide, as in Figure 2.

(*c*) With a plain pin make perforations through both films at each landmark.

(*d*) Construct intersecting lines, F_1A_1 and F_2A_2, from target footpoints to perforations representing the landmarks of the promontory. The relationship between respective landmarks and footpoints can readily be determined by inspection, since

lines drawn from the footpoints to the wrong landmarks will not intersect. The intersection thus obtained, A_2, represents the projection of the sacral promontory upon the film (Fig. 3).

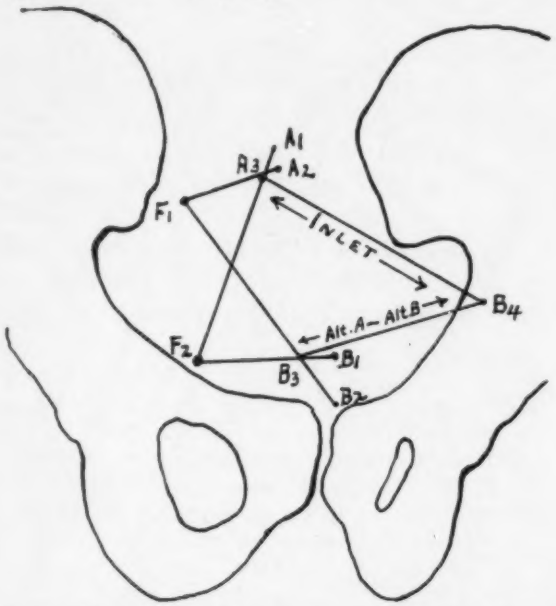

FIG. 3. Tracing from Figure 2, showing measurement of anteroposterior diameter of the pelvic inlet. A_1 and A_2, images of sacral promontory; A_3, projection of sacral promontory; B_1 and B_2, images of symphysis pubis; B_3, projection of symphysis pubis; F_1 and F_2, target footpoints; B_4B_3 = altitude B – altitude A, at right angles to A_3B_3; A_3B_4 = anteroposterior diameter of pelvic inlet.

N. B.—A^1, A^2, B^1, B^2 should read from above downward A^2, A^1, and B^2, B^1 (see Fig. 1).

(*e*) In a similar manner intersecting lines from the footpoints to the perforations representing the landmarks of the symphysis pubis are constructed. The intersection of these lines, B_3, represents the projection of the symphysis pubis upon the film.

(*f*) Construct a line, A_3B_3, joining the points of intersection obtained in *d* and *e* above. This line is the projection of the anteroposterior diameter of the inlet upon the film.

(*g*) Using the formulae previously d-e scribed, compute the altitudes of the extremities of the anteroposterior diameter of the pelvis represented in Figure 1 by AA_3 and BB_3. Figure 4 is a diagram showing the detail at this juncture.

It can be seen that if the line AK has been constructed parallel to the line A_3B_2 it is equal to it, since the altitudes are parallel. AB is the hypotenuse of a right

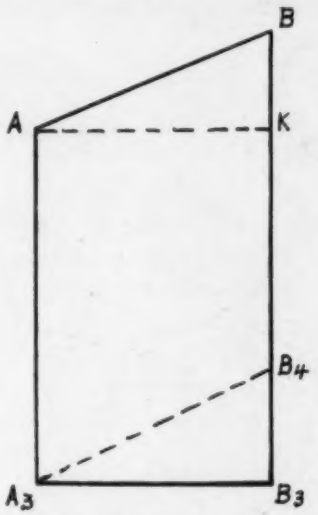

FIG. 4. Detail diagram of relation of diameter AB, and its projection A_3B_3. AA_3 and BB_3, altitudes at promontory and symphysis; A_3B_4 constructed parallel and therefore equal to AB; $B_4B_3 = BB_3 - AA_3$: A_3B_4 = hypotenuse of triangle $A_3B_3B_4$.

triangle, the sides of which are the projection of the diameter as obtained on the film in the manner described under (*d*) and (*e*) and the difference in altitudes is computed. It therefore follows that a line constructed perpendicular to A_3B_3 at either of its extremities will form with it such a right triangle.

(*h*) Measure the line A_3B_4. This is the actual anteroposterior diameter of the inlet. Figure 3 is a tracing of superimposed films showing the construction of this diameter, A_3B_4.

(*i*) Figure 5 shows the construction by means of which the transverse diameter of the inlet is obtained. The intersecting lines A_1F_1 and A_2F_2 determine the projection of one extremity of this diameter. Similarly, the intersecting lines F_1B_1 and F_2B_2 determine the projection of the other extremity. The distance between these points of intersection as shown above represents the projection of the transverse diameter of the inlet. In this particular case, the

spread of the images represented by A_1A_2 and B_1B_2 are equal to each other. Therefore, the altitudes AA_3 and BB_3 (Fig. 1) are equal to each other. It naturally follows that the transverse diameter of the inlet

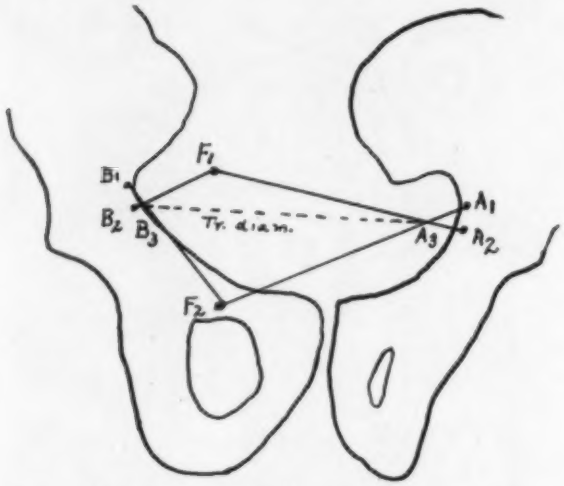

Fig. 5. Tracing from Figure 2, showing measurement of transverse diameter of pelvis. A_1 and A_2, images of right side of inlet; A_3, projection of right side of inlet; B_1 and B_2, images of left side of inlet; B_3, projection of left side of inlet; A_3B_3, projection of transverse diameter of inlet.

N. B.—A^1, A^2, B^1, B^2 should read from above downward A^2, A^1, and B^2, B^1 (see Fig. 1).

represented by AB (Fig. 1) is equal to its projection A_3B_3 (Fig. 5) since it is parallel to it.

CONCLUSION

This method has been applied in the measurement of a dried pelvis placed in various positions at random. In no instance was an error greater than 1 mm. recorded. It is therefore justifiable to conclude that similar accuracy is attained in measurement of the living female pelvis, since no difficulty is encountered in identifying the necessary landmarks when the films are placed in a stereoscope.

SUMMARY

1. A parallax method of roentgen pelvimetry, highly accurate and of simple clinical application, based upon principles described by Hodges and Ledoux, is presented.

2. The results obtained with this method in measuring a dried pelvis and several patients were extremely satisfactory.

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PRIMARY LYMPHOSARCOMA OF THE DUODENUM*

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PRIMARY lymphosarcoma of the duodenum is rare. Libman,[10] in 1900, reported 59 cases of primary sarcoma of the intestinal tract. Of the 42 in which the location of the tumor was given, only 15 were in the duodenum. Three of these duodenal sarcomata were lymphosarcoma in type. Graves[5] found 249 cases of lymphosarcoma of the small intestine in the literature up to 1919; their exact sites of origin were not mentioned. Ullman and Abeshouse[15] added 126 cases to Graves' series. Of these, 4 were limited to the duodenum alone. Cheever,[1] in 1932, reported 16 cases of primary lymphosarcoma of the gastrointestinal tract. Of these none was in the duodenum. He considered the duodenum the most infrequent site of involvement in lymphosarcoma of the small intestine.

The rare involvement of the duodenum by sarcoma is in contrast to the frequency of carcinoma in this region. Kellogg and Kellogg,[9] in 1933, found 57 (46 per cent) of 124 cases of small intestinal malignant disease of all types to be in the duodenum.

In 1935, Prey, Foster and Dennis[12] published a careful analysis of all authentic cases of primary duodenal sarcomata. They found the reported cases difficult to analyze because of the confusion of terminology, frequent incompleteness, and the ambiguity of the diagnoses. The total number of instances of duodenal sarcomata was thus limited to sixty-one. Thirty-five of these were apparently definite lymphosarcomata. They added 1 case to this group. Since 1935 the available literature contains reports of but 3 more primary lymphosarcomata of the duodenum (von Hrabovszky,[16] Grilli[6] and Frugoni[4]).

PATHOLOGY

Pathological text and reference books discuss lymphosarcoma of the duodenum either briefly or not at all. Ewing[2] describes the process in the small intestine as a localized thickening of the submucosa with or without ulceration. This extends laterally and involves all of the intestinal layers. Polypoid tumor masses may project into the lumen. Kaufmann[8] states that the small intestinal lesions may be plaque like or diffuse, possibly leading to aneurysmal dilatation as the muscularis is destroyed. Ulceration or stenosis may follow as the tumor increases in size. The resultant duodenal deformity is well described by Prey, Foster and Dennis in whose case the entire horizontal limb of the duodenum was described as "rigid" and "tube-like" when seen at operation.

ROENTGEN FINDINGS

Roentgen examinations were mentioned in 7 cases in the series collected by Prey, Foster and Dennis. Storch's[13] case showed a lesion at the duodenojejunal junction where the mucosal pattern was distorted and there was "disturbed motility." Similar findings were present in Freud's[3] 2 cases, in 1 of which the lesion was located in the second and third portions of the duodenal loop, and in the other in the second portion only. The case of Strauss, Bloch, Friedman and Hamburger[14] showed "an irregularity" of the second portion of the duodenum. Obstruction was the only roentgen finding noted in 1 case by Illoway,[7] and in another by Prey, Foster and Dennis. In the former, the obstruction was apparently in the lower portion of the descending limb, and in the latter the

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Fig. 1. Case 1.

duodenal bulb was greatly dilated above a mass in the second portion which was large enough to cause a pressure defect in the stomach. Mostowska[11] noted that the roentgenological findings in his case led to the diagnosis of "chronic perforating peptic ulcer."

The 3 cases reported since 1935 all have mention of the roentgen findings. von Hrabovszky's[16] case was correctly diagnosed as lymphosarcoma of the duodenum because of stiffening of the involved portion and a loss of mucosal markings. Frugoni[4] indicated that the duodenal bulb above the lesion in the descending limb of the duodenum showed exaggerated mucosal markings while those of the diseased portion were lacking. Grilli[6] reported that the lesion was correctly interpreted but gave no further information.

CASE REPORTS

Two cases of primary lymphosarcoma of the duodenum are here reported.

Case 1. (Unit No. 428607). An Italian baker, aged forty-eight, was admitted to the hospital in August, 1934, complaining of weakness, loss of weight and vomiting of three months' duration and gradually increasing in severity until the vomiting became a daily occurrence. A cholecystotomy had been done in 1929 because of recurrent attacks of right upper quadrant pain without jaundice. Eighteen months later a recurrence of the pain led to another operation for adhesions.

On examination the patient appeared to be chronically ill and slightly jaundiced. There was no general glandular enlargement. The heart was slightly enlarged to the left. In the right upper quadrant a fistula from his last operation was noted and a "questionable" mass was felt.

The blood showed a hemoglobin of 73 per cent with 3,600,000 red cells and 8,600 white cells. The urinalysis and the blood Wassermann reaction were both negative. The stools were clay colored and the vomitus bile stained.

On roentgen examination of the gastrointestinal tract (Fig. 1) no abnormalities of the stomach or of the duodenal bulb were noted. Beginning about 2 cm. below the junction of the first and second portions of the duodenum the lumen was markedly narrowed for a distance of several centimeters, extending well around to involve the lower part of the third portion. The mucosal pattern was obliterated, suggesting destruction of the mucous membrane. The walls were stiffened and no peristaltic movements were seen.

Because of the persistent vomiting, a posterior gastroenterostomy was done. At operation a narrowed, thickened and stiff segment of the duodenum, 6 cm. in length, was noted in the region seen to be abnormal on the films. A biopsy of the involved wall failed to show tumor tissue, being largely fibrotic with chronic inflammatory cells scattered through the section. The postoperative course was uneventful, and a re-examination of the gastrointestinal tract showed a satisfactorily functioning gastroenterostomy with no change in the duodenal lesion.

On November 6, 1934, eleven weeks after his discharge from the hospital, the patient was re-admitted for gradually increasing but painless jaundice of one week's duration. No change other than the jaundice was noted on examination. The serum bilirubin was 3.9 mg. per cent. At operation the duodenal tumor was found to be more extensive with involvement of the head of the pancreas and with obstruction to the common duct which was widely dilated. A choledochogastrostomy was done. Examination of tissue from the involved portion of the pancreas showed only fibrosis. Repeated roentge

examinations showed no change in the duodenal contours.

Rapid improvement followed, but lasted for only three weeks when severe right upper quadrant pain radiating to the right costovertebral angle caused him to return. After two months, because the pain was only partially controlled by opiates, and because the diagnosis of lymphosarcoma had been suggested by the roentgenologist, the patient was given radiotherapy. A mass had been found in the right upper quadrant, and this area was treated with small roentgen doses (125–150 r) at one or two day intervals (200 kv., 25 ma. 2 mm. copper, 1 mm. aluminum, 50 cm. target-skin distance, with fields of 15×15 cm.). At the end of three and one-half weeks, with a total of 1,200 r anteriorly and 750 r posteriorly, the mass had disappeared and the patient was free from pain. No roentgen evidence of a change in the duodenum was found. His period of relief was brief, however, and further roentgen therapy was given as the pain recurred.

Jaundice returned and uncontrollable pain made it impossible to move the patient. Ascites appeared with severe constipation. On January 14, 1936, about sixteen months after the first admission, death followed a few hours of coma and a period of thin, thready pulse.

At necropsy (sixteen months after the roentgen examination (Fig. 1)) the duodenum was found to be tremendously thickened and firm. Its wall was largely destroyed and replaced by tumor tissue throughout a length of 10 cm. beginning at the pylorus. In some areas ulcers were apparent, and in others small nodules projected into the lumen. The lumen was narrow in the first portion and widened in the second. The mass extended posteriorly, invading the inferior vena cava and connecting it with the cavity of the duodenum. On microscopic examination the duodenum was almost entirely destroyed by invasion of the tumor cells. These cells were fairly uniform in size with large, round nuclei and scanty cytoplasm. Mitotic figures were infrequent. Considerable fibrous tissue and many plasma cells were present. Sections of the stomach showed early invasion of the submucosa. The pathologic diagnosis was lymphosarcoma of the duodenum with extension to the stomach and to the inferior vena cava.

Case II (Unit No. 464534). A Porto Rican clerk, aged forty, came to the hospital in September, 1935, because of intermittent burning epigastric pain of one year's duration. The pain

Fig. 2. Case II.

occurred from two to two and one-half hours after meals and was relieved by the ingestion of food. In the year of his illness he had lost 11 pounds. No nausea or vomiting was reported.

Physical examination revealed nothing of importance except undernourishment, pallor and epigastric tenderness.

The blood showed a hemoglobin of 95 per cent with 5,000,000 red blood cells and 11,600 white blood cells of which 67 per cent were polymorphonuclears, 31 per cent lymphocytes, one per cent each monocytes and eosinophiles. Examination of the urine and of the stools was negative as was the blood Wassermann reaction. A gastric expression showed the free hydrochloric acid to be 39 and the total acid, 51.

On roentgen examination the stomach and duodenal bulb revealed no evidence of organic disease. The remainder of the duodenum appeared narrow, stiff and smooth. The mucosal markings were obliterated and peristaltic movements were absent (Fig. 2). These findings were confirmed on re-examination.

Because of an increase in the pain and a further loss in weight the patient was operated upon. The only abnormality was a pathologic process found on opening the duodenum. The mucosa of the descending portion was normal in color but granular ("pig-skin") in appear-

ance. A biopsy of this area disclosed elevation and distortion of the mucosa by nodules of lymphoid tissue. Most of the cells were of the small lymphocyte type. Many mitotic figures were seen in the central portions of these lymphoid masses where the cells more nearly resembled those of germinal centers. The muscular coat was not involved. This was interpreted by the pathologist as lymphosarcoma of the duodenum of the giant follicular cell type. A posterior gastroenterostomy was done.

Roentgen therapy was given in small (70–100 r) daily doses through an anterior portal (200 kv., 25 ma., 2 mm. copper, 1 mm. aluminum, 50 cm. target-skin distance). The field was centered over the duodenum and measured 10×15 cm. A total of 2,480 r was given over a period of thirty-five days, during which the patient was slightly nauseated. He was placed on a high vitamin, high caloric diet with insulin under which he gradually gained weight, and the gastric symptoms slowly disappeared.

In March, 1936, after two and one-half months, the patient received a second course of treatment through a posterior field, with the same factors and a total of 1,500 r in a period of two weeks. Since then, as pain and tenderness have recurred, roentgen therapy in small doses has given relief.

In April, 1937, a mass was found in the upper abdomen and on roentgen examination was seen to occupy a position below the pylorus and mesial to the descending limb. The lumen was not obstructed. After further radiotherapy the mass decreased in size.

At the present time (November, 1937) the patient is active, comfortable and maintaining his weight.

SUMMARY

Lymphosarcoma of the duodenum is an infiltrative process which may involve fairly extensive portions of the wall, causing destruction of the mucous membrane and stiffening.

Only ten of the thirty-nine authentic cases reported in the literature were studied roentgenologically. Two cases are added herewith. Smoothing of the barium-filled duodenum, due to destruction of the mucous membrane, and absence of mucosal folds over a large portion of the duodenum seem to be characteristic effects of the disease, although merely obstruction has been reported. Differentiation from carcinoma would probably be difficult or impossible if only a small area were involved. In the two cases herewith reported, as well as others in the literature, the extent of the involvement suggested the possibility of this disease. The diagnosis is well worth while because of the palliation offered by radiotherapy.

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THE ROENTGENOLOGIC APPEARANCE OF INTUSSUSCEPTED TUMORS OF THE COLON, WITH AND WITHOUT BARIUM EXAMINATION

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INTUSSUSCEPTION of one part of the intestine into another is commonly thought of as a dramatic event, necessitating immediate surgical interference. While this is true in a large number of cases, there are others in which repeated more or less severe attacks of intussusception produce the clinical picture of chronic abdominal disease. The clinical diagnosis is often difficult in these chronic cases, and even in acute cases the diagnosis is by no means easy. Roentgen examination offers help in acute and chronic cases, and it usually permits a definite diagnosis.

The first description of the roentgen appearance of intestinal intussusception was given by Ladd, who in 1913 reported a case examined by George. Since then numerous papers on this subject have appeared, most of them being case reports, a few are more extensive as, for example, those by Meda and Castronovo in the Italian literature, that by Laurell in the Scandinavian literature and that by Sussman in the American literature, who in 1932 reported 5 cases of his own. Among other papers which have been published on this subject are those by Ashbury, Golden, Holmgren, Lehmann, Muff, Regnier, Reiser and Gurniak, and Stewart and Illick.

While previous reports have dealt with the appearance of the intussuscepted gut after the introduction of barium by mouth or by rectum, this paper will particularly stress the importance of the examination of the abdomen before the introduction of contrast substances.

The roentgen appearance of intussusception varies, in some degree, according to its localization within the intestinal tract. This paper will be confined to a discussion of intussusception of the large bowel (colocolic and cecocolic). The small intestine may be involved secondarily. The pure colocolic type of intussusception is generally thought to be rare, only a small number of colocolic intussusceptions having been reported; but our own experience indicates that this type is not uncommon.

This paper is based on the examination of 11 patients with intussusception of the large bowel seen during the past three and a half years. All patients were adults, the age varying from thirty-two to seventy-eight years. In all cases, a tumor of the large intestine was the cause of the intussusception.

GROUPING IN REGARD TO LOCALIZATION

In 4 cases the cecum was the site of the tumor which had intussuscepted into the transverse colon (Cases I, II, III, IV). In 2 cases a tumor of the ascending colon had intussuscepted into the transverse colon (Cases V and VI). In 3 cases tumors of the hepatic flexure had intussuscepted into a distal part of the transverse colon (Cases VII, VIII and IX). In 1 case, a tumor of the transverse colon had intussuscepted into the descending colon (Case X), and finally a tumor of the sigmoid had intussuscepted into a lower portion of the sigmoid (Case XI).

HISTOLOGY

In 7 cases (Cases I, II, III, IV, VI, VIII and XI), the intussuscepted tumor was an adenocarcinoma. In 3 cases (Cases V, VII and X), the tumor was a pedunculated submucous lipoma. It is noteworthy that the lipomata showed partial necrosis and ulceration in all cases; a similar appearance was seen in one of Sussman's cases. These

changes are probably due to the repeated intussusception of the tumor, and explain the bleeding which was present in some of these cases. The necrotic surface may produce a granulated appearance, whereas the remainder of the lipoma is smooth. In 1 case (Case IX), the histology is not known (no operation).

ANALYSIS OF THE ROENTGEN SIGNS

A number of roentgen signs are found in patients with intussusception of the colon. They will be analyzed in the following paragraphs. Not all the signs are present or demonstrable in a given case. Some of the signs are characteristic of intussusception, whereas others may also be found in other conditions.

The majority of the signs are easy to understand if one realizes that three concentric cylinders are present in the region of the intussusception (Regnier). They form a narrow central canal which is surrounded by a thin peripheral sheath. Central canal and peripheral sheath are separated by a wide space which is occupied by the intussuscepted mesentery as well as by the tissue of two complete intestinal walls, namely those of the in- and out-going part of the intussuscepted loop (see Fig. 1).

A large variety of roentgen appearances of intussusception has been described by various authors (see summaries by Meda and Sussman). Actually, all of these types represent more or less the same anatomical process, characterized by Figure 1. Only the degree of filling of the peripheral sheath and of the central canal, as well as the filling of the gut proximal and distal to the intussusception varies, disclosing different areas of the intussusception.

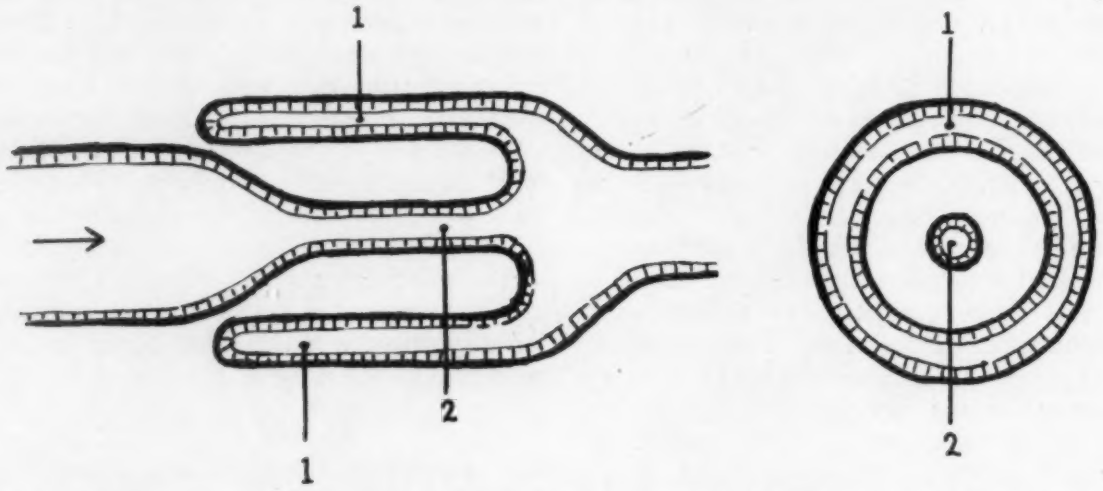

Fig. 1. Diagrams showing the three concentric cylinders in the region of the intussusception. These cylinders form a shallow peripheral sheath, *1*, and a narrow central canal, *2*. The wide space between them is occupied by the intussuscepted mesentery as well as by the wall of the in- and of the outgoing portion of the intussuscepted loop.

Three types of examination are possible: the examination without contrast substance ("flat film"), the barium enema and the peroral barium examination. A flat film should be taken in any questionable abdominal case, and certainly in any case suggestive of intussusception. An enema should follow, for diagnostic as well as therapeutic reasons. A peroral examination is usually not necessary. It should be done if the preceding examinations have not been conclusive. It is, of course, usually not advisable in the presence of definite obstruction.

(1) *Barium Enema.*

(a) The enema may stop suddenly with the formation of a cap which corresponds

to the head of the intussusception (Reiser and Gurniak, Sussman; our Cases v, viii and x) (Figs. 9 and 14).

(b) The barium may enter the sheath which surrounds the intussuscepted gut (filling between outer and medial cylinder). Two peripheral lines of barium outlining the profile of the nonfilled intussuscepted gut produce a very characteristic picture. The first cases of intussusception reported in the literature belong to this group (Ladd, reporting George's case in 1913, Lehmann in 1914). Frequently, circular bands of barium, more or less parallel, surround the intussuscepted gut connecting these two lines (Ladd, Muff, Castronovo, Renander, Sussman, *et al.;* our Cases i, iii, v, vii, viii and ix) (Figs. 3, 4*A* and 12*B*). The spiral-like picture formed by these lines around the nonfilled intussuscepted gut is extremely characteristic of intussusception. This is more often seen after evacuation of the main portion of the enema. Much discussion has taken place concerning the etiology of these lines. I believe they are probably due to telescoping of the portion of intestine into which the intussusception has taken place.

The sheath often acts like a blind alley preventing any further filling of the colon. The pressure of the enema may then produce reduction of the invagination (Cases i, iii and v). This reduction was accompanied by a loud sound in one of our cases (Case v).

(c) In other cases, the enema enters the lumen of the intussuscepted gut ("central canal"). This central canal is usually narrow and has longitudinal rugae. It is separated from the sheath by the wide nonfilled area which is occupied by two wall thicknesses of intestine and by the intussuscepted mesentery (Reiser and Gurniak's case; our Cases v, vi, viii and ix) (Figs. 10 and 13). The narrowing ends fairly abruptly at the entrance of the intussusception (Case ix) (Fig. 13). The colon proximal to the intussusception may or may not be dilated and it is shortened, depending on the degree of intussusception.

Air insufflation of the colon produces essentially the same changes as the barium enema. The central canal is sometimes more easily outlined by this method, as may also be the invaginated tumor.

(2) *Peroral Examination.* The examination after oral administration of barium shows the same principal changes: namely, filling of the central canal of the intussuscepted gut as well as filling of the sheath. Dilatation of the proximal gut is more commonly seen during the peroral examination, particularly in cases of ileocecal intussusception (Case i). The sudden change in caliber of the gut marking the beginning of the intussusception is more easily demonstrable (Case i) (Fig. 4*B*), and may have the shape of a bird's beak (Castronovo). The filling of the central canal is usually very striking (Regnier; our Cases i, ii and v) (Figs. 4*B*, 5, and 10*B*). This linear filling, if present without barium in the surrounding sheath, may produce interesting differential diagnostic errors (see under differential diagnosis). The intussusception is usually more extensive when examined by oral examination than by barium enema, due to the fact that partial or total reduction of the intussusception may be produced by the enema. For similar reasons, one usually sees more gut intussuscepted after evacuation of the enema than during the injection.

The diameter of the intussuscepted sausage-shaped, soft tissue mass may enlarge with increasing degree of intussusception. This is mainly due to the added amount of intussuscepted mesentery.

(3) *Flat Film.* After reviewing the large amount of data gathered regarding the examination of intussusception with barium, it is surprising to see how few facts have been published in regard to the examination without any contrast substance. If one considers the serious condition of some of the patients with intussusception it is obvious that any supporting diagnostic facts which could be obtained by such type of investigation might be of considerable practical importance.

Kloiber emphasized the diagnostic value of the presence of air- and fluid-filled dilated loops of small intestine in cases with obstruction. The sign may—in connection with the clinical picture—be very helpful, though it is not specific as it may be produced by any kind of obstruction and also by paralytic ileus.

Castronovo described absence of gas in the hepatic flexure, presence of small intestinal loops in the area usually occupied by the intussuscepted colon, and a particular shape of the terminal loop of the ileum.

Among these signs, the absence of the normal pattern of the air- and fecal-filled cecum and ascending colon in cases of ileocecal invagination is particularly common and valuable.

Our cases showed, in addition to these signs, others which are easily understood from the anatomical picture of the intussusception and from a comparison with the appearance found at the barium examination.

The importance of these signs may be emphasized by the following fact. Six of our cases had a flat film examination or views of the invaginated area comparable with a flat film. All 6 showed definite pathological changes. Obstruction was the only demonstrable roentgen sign in 1 of these cases, whereas the rest of the cases produced changes on the flat film which I believe to be almost pathognomonic of intussusception. They consist of changes in the region of the intussusception and of the intestine proximal to it.

The area of intussusception is characterized by a sausage-shaped, homogeneous shadow representing the intussuscepted portion of intestine. This area may be surrounded by the air-filled sheath, represented by two straight or undulating peripheral air stripes (Cases I and V) (Fig. 7), or by air rings surrounding the central "sausage" (intussuscepted gut) (Cases I, V, VII and X) (Figs. 6 and 12). They correspond to the characteristic barium rings mentioned above.

The shadow of the intussuscepted gut is differentiated from that of a fecal mass by its marked homogeneity compared with the mottled appearance (mixture of air and feces) of fecal material. The diameter of the "sausage" varies with the degree of intussusception. It often becomes wider with increasing degrees of intussusception. The tumor causing the obstruction can sometimes be seen at the head of the "sausage" (Cases I and V) (Figs 2 *A* and 7). Unless the peripheral sheath, the part of bowel into which the intussusception has taken place, contains air, the diagnosis of intussusception may be difficult on a flat film. In such a case a long homogeneous shadow (the "sausage") in a region where one would expect the air- or fecal-filled colon may suggest the correct diagnosis. One of our cases (Case IV) showed in addition a concave lower end of the "sausage" corresponding to the inverted cecum.

A very characteristic picture is obtained if the central canal, the lumen of the intussuscepted gut, contains air on the flat film. In such a case one sees a narrow air-filled lumen surrounded by a thick soft tissue cylinder. This cylinder surrounding the central air-filled canal produces a doughnut-like picture, if the intussuscepted gut is seen end on, e.g., at a flexure (Case X) (Fig. 14).

The gut entering the area of intussusception produces a typical picture if outlined by air. Castronovo described this appearance of the terminal ileum in cases with ileocecal intussusception and compared it to a bird's beak. The same characteristic cone-shaped narrowing can occur in the colon as one of our cases with colocolic intussusception demonstrated (Case X) (Fig. 14*B*).

Proximal to the intussusception, our cases showed on the flat film an unusually short right colon, as outlined by air and fecal material or a complete absence of colon pattern in this area. In 2 cases gas-filled small intestinal loops were seen in its place (Cases V and VII). Gross obstruction with distended air-filled gut proximal

to the intussusception was present in 2 of the cases (Cases x and xi) (Fig. 14). All these changes proximal to the intussusception are noteworthy but not so specific as those seen in the region of the intussusception itself, as outlined before.

ETIOLOGY OF INTUSSUSCEPTION AND ITS INFLUENCE ON THE ROENTGEN APPEARANCE

Intussusception may be caused by a large variety of factors, by tumors of the intestine, Meckel's diverticulum, thickening of a Peyer's patch, by any localized area of the gut with increased rigidity (Laurell) (we recently saw a case of hypertrophic tuberculosis of the terminal ileum with intussusception of the diseased ileum into the colon), and by other as yet undetermined factors. In adults, tumor is by far the most common cause. Polypoid and pedunculated tumors are particularly inclined to intussuscept, though intussusception due to infiltrating, and even annular tumors occurs (Case vi).

The roentgen appearance is basically the same regardless of the source of the intussusception. It may therefore be impossible to state the causative factor. If, however, a tumor is intussuscepted, it always forms the head of the intussusception. Frequently it can be recognized in this position on flat films (Cases i and v), by enema (Cases i, ii, iii, v, vii, ix and xi) and at times by peroral examination (Cases ii, v and ix). The smooth, granulated or ulcerated surface of the tumor is best seen on films taken with selected localized pressure after evacuation of the enema, or after insufflation of the colon with air. In nearly all of our cases (10), the tumor was demonstrated. The eleventh case did not have a barium examination. The tumor was not visible on the flat film in this case.

DIFFERENTIAL DIAGNOSIS

The differential diagnosis is concerned with two questions:

(1) Is an intussusception present?

(2) What type of intussusception is present?

The first question is usually easily answered in fully developed cases. The roentgen signs of intussusception are so characteristic that there is no doubt about the diagnosis.

More difficult are cases in which no filling of the peripheral sheath is visible; in other words, if one sees only a cap-like block at the examination with barium enema. An obstructing, not intussuscepted polyp could produce the same picture. A barium meal would give the necessary additional information. The obstruction present prohibits, however, this type of examination in many instances. A thorough study of the soft tissue changes proximal to the obstruction makes a peroral examination superfluous in many instances by outlining the intussusception.

Two diagnostic pitfalls may be mentioned. The inverted cecum exhibits a defect which may simulate that of an extrinsic mass. Faber reports such a case in which roentgenologically a large pericecal granuloma had been diagnosed. Inasmuch as a defect of the cecum in intussusception usually does not occur without the presence of other roentgenological signs of intussusception, a differential diagnosis should not be difficult if one only thinks of the possibility of intussusception.

Recently, we saw films in consultation (not included in this report) in which the presence of a markedly narrowed piece of gut in the neighborhood of the ileocecal valve had led to the diagnosis of ileitis. The narrow lumen of the filled central canal in a case of ileocecal intussusception had been mistaken for the "string sign" of ileitis. The mucosal pattern of the narrow central canal is different from that of ileitis at the fibrostenotic stage, and other roentgen signs of intussusception will usually be present, as they were in this case.

What type of intussusception is present? The question of what part of the gut is intussuscepted is important to the surgeon. The picture is generally simple in colocolic intussusception. Enough colon is usually visible proximal to the intussusception,

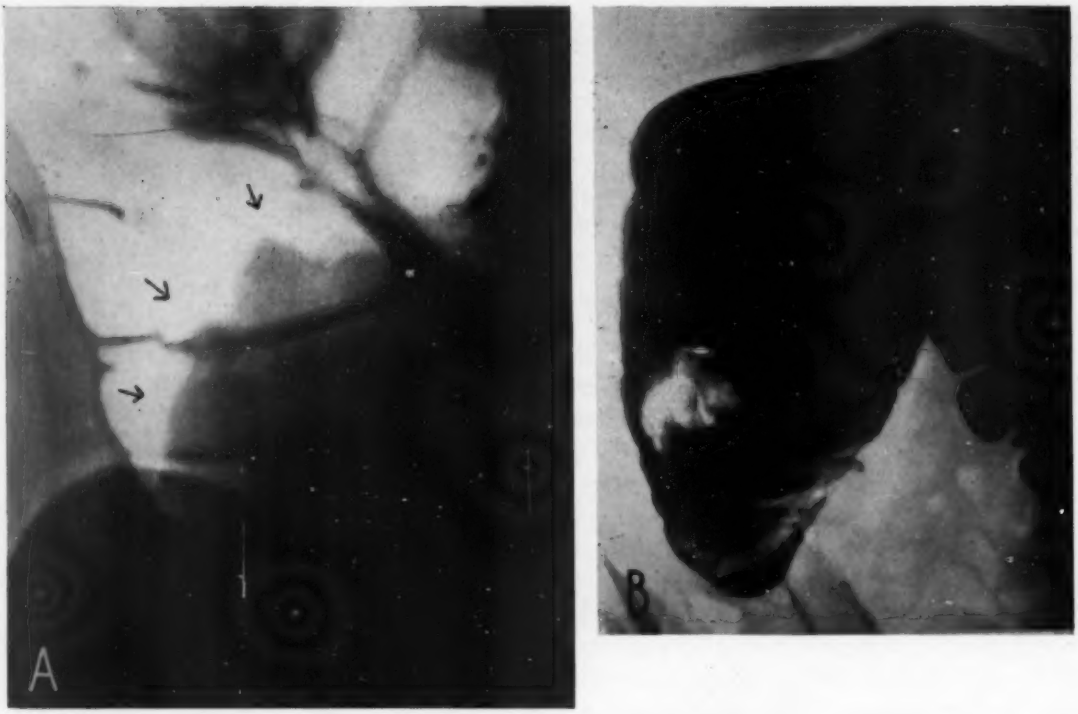

Fig. 2. Case 1. *A*, flat film without barium showing the lobulated tumor mass protruding into the air-filled ascending colon (arrow). *B*, barium enema shows a corresponding filling defect of the cecum and ascending colon. Cup formation of the slightly intussuscepted cecum.

either by the appearance of the soft tissues or by the peroral examination, to mark the beginning of the intussusception.

Difficulties may arise in cases of intussusception around the ileocecal valve. The differentiation of colocolic from ileocolic intussusception may be difficult, if the ascending colon represents the intussuscepted gut. Ileocolic intussusception may also simulate cecocolic (also called ileocecal) intussusception. In other words, it may be difficult to decide if the intussuscepting tumor arises from the small intestine, from the cecum or from the ascending colon, a decision which may be of prognostic and therapeutic importance.

The diagrammatic sketches shown in Figure 15 may facilitate the differential diagnosis.

Cecocolic (ileocecal) intussusception is characterized by the fact that the cecum is routinely inverted, whereas it may not be involved in the colocolic and ileocolic types.

The two latter types are differentiated from each other by the following signs:

The continuity of the outline of the ascending colon is interrupted in the region of the beginning of the intussusception in the colocolic type. It is not interrupted in the ileocolic type.

The ascending colon appears to be shortened if the proximal colon is intussuscepted. If the intussusception is very marked, cecum as well as ileum will be involved in all three types, and an identical roentgen picture may result. The larger amount of mesentery inverted in cases of extensive ileocolic intussusception will produce a marked shortening of the curve described by the uninvolved part of the colon, a sign which is not quite so characteristic for the other types.

One of our cases (Case v) shows that a tumor of the ascending colon may invaginate far into the transverse colon, and that the cecum may still remain outside the intussusception (Fig. 10*A*). This phenomenon may be explained by the great amount

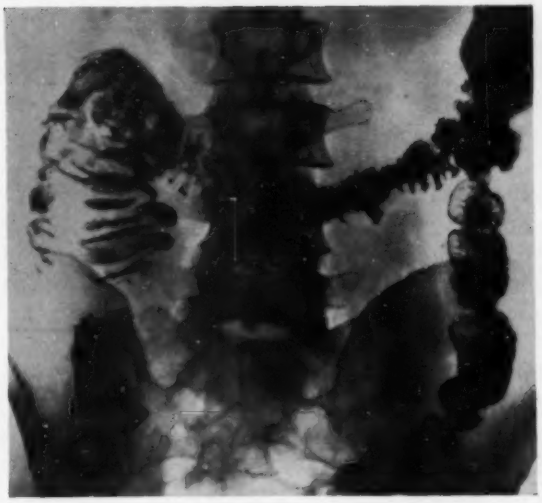

Fig. 3. Case 1. After evacuation of the barium enema the tumor lies in the region of the hepatic flexure. Wide but short ascending colon containing the intussuscepted gut. Barium lines in the shallow peripheral sheath. Dilated small intestinal loop.

of elasticity inherent in the normal colon.

The clinical symptomatology of intussusception will not be discussed. Before concluding, I can, however, not refrain from stressing a clinical symptom which was very striking and which occurred in 8 of our 11 cases; namely, a history of repeated cramp-like pains in the abdomen, usually of short duration, more or less severe, sometimes accompanied by fainting spells. Between these attacks, which in one case extended over a period of ten years, the patients may feel perfectly well. These cramp-like, colicky pains, the location of which varies according to the region of the intussusception, produce in some cases the clinical picture of a chronic, intermittent abdominal disease and appear to be so characteristic that it seems worth while to emphasize them even in a purely roentgenological report. It is likely that complaints of patients with cancer of the colon are more commonly than is usually assumed, due to repeated attacks of minor degrees of intussusception.

CASE REPORTS

I. Cecocolic (Ileocecal) Intussusception

Case 1. G. A., male, aged thirty-two. A history of eight months' gnawing, right lower abdominal pain, at times cramp like. Three months ago, appendectomy was performed on the outside without improvement of symptoms. *Physical examination:* Resistance in the right lower abdomen. No blood in stools. *Roentgen examination:* Flat film showed a homogeneous,

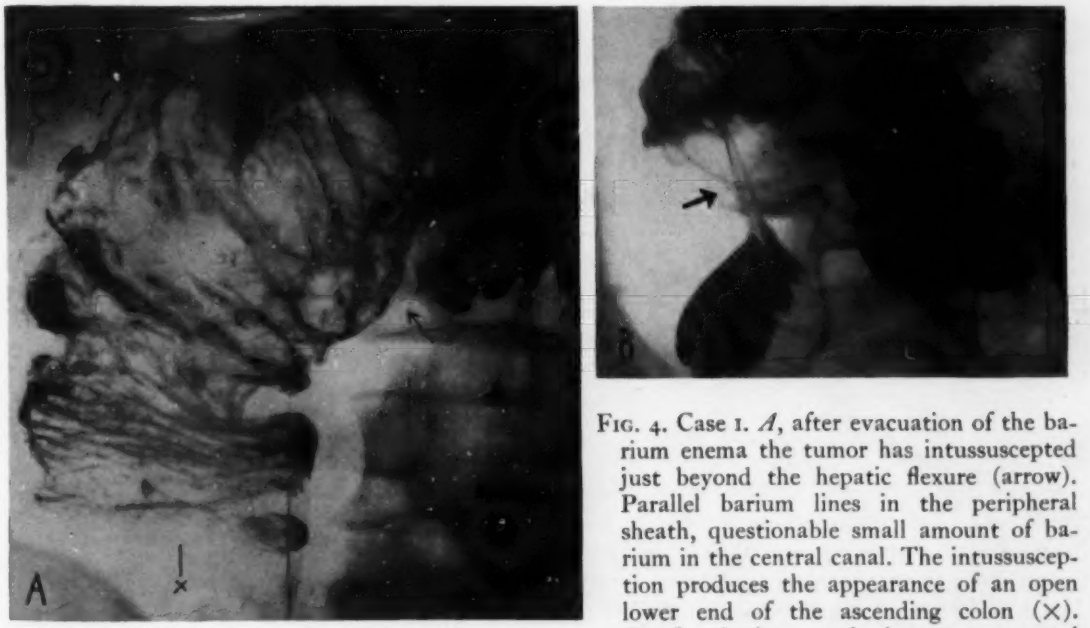

Fig. 4. Case 1. *A*, after evacuation of the barium enema the tumor has intussuscepted just beyond the hepatic flexure (arrow). Parallel barium lines in the peripheral sheath, questionable small amount of barium in the central canal. The intussusception produces the appearance of an open lower end of the ascending colon (×). *B*, after barium meal, the narrow central canal is filled with barium (arrow) distal to a dilated small intestinal loop.

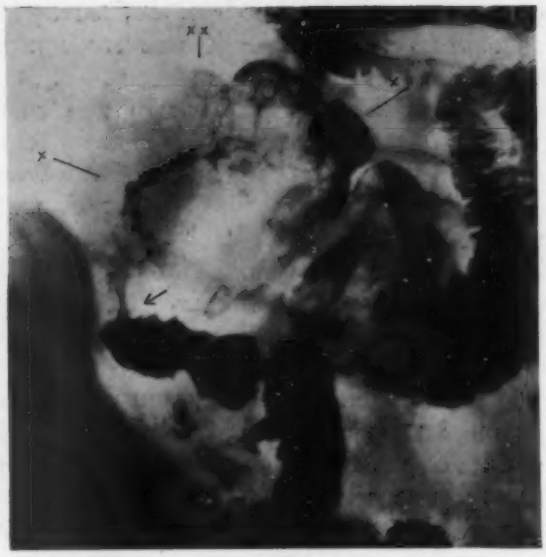

Fig. 5. Case II. Carcinoma at the ileocecal valve intussuscepted into the transverse colon. Peroral examination. Slightly dilated small intestinal loop entering the colon in the region of the hepatic flexure. The narrow central canal is filled with barium (×). It is surrounded by the soft tissue mass of the intussuscepted intestine (××). Barium filling of the peripheral sheath around this portion of intestine is seen more distally (×××). Arrow indicates the beginning of the intussusception.

soft tissue mass in the region of the cecum and ascending colon, lobulated at its upper end. The mass was surrounded by an air cylinder and by air spirals. *Barium enema:* A soft mass was demonstrated filling the ascending colon and the beginning of the transverse colon. The cecum could not be filled, the lower end of the filled portion of the ascending colon being concave. Distention of the colon with air or barium displaced the defect towards the cecum and reduced the defect in size. A lobulated mass was constantly seen at the tip of the intussusception. Parallel barium and air lines surrounded the large mass. Ileum not filled by enema. Examination by mouth showed widened terminal ileum which continued into a narrow canal lying within the center of the mass seen in the ascending colon. Diagnosis was intussuscepted tumor of the cecum. *Operation:* Sessile adenocarcinoma at the tip of the cecum measuring 4 x 5 cm. and elevated 2.5 cm. Marked edema and redness of the terminal 7 cm. of the ileum, corresponding to the intussuscepted area of the ileum.

Case II. E. C., female, aged fifty-seven, gave a history of three months' griping pain in lower abdomen coming on after eating. Marked loss of weight. *Physical examination:* Pale woman. Slightly tender, movable, orange-sized mass to the right of the umbilicus. *Clinical diagnosis:* Cancer of the stomach. Roentgen examination showed normal stomach. At the end of six hours the terminal ileum was filled. Cecum not visible. Large filling defect in the hepatic flexure surrounded by thin circular lines and partially filled haustral markings. Traces of barium connected in a thin line the terminal ileum with this mass. Soft tissue mass was seen to surround this streak of barium. Barium enema examination stopped in the region of the mass in a sharp semicircular line. The large soft tissue mass was seen again in the region of the hepatic flexure with a thin central line of barium in the proximal part of this soft tissue mass. *Diagnosis:* Lobulated mass in the region of the hepatic flexure with intussusception. *Operation:* Adenocarcinoma of the ileocecal valve.

Case III. V. P., female, aged fifty-six, complained of increasingly severe recurrent attacks of lower abdominal pain for six months. Lump in the right side of the abdomen noted two weeks before entry. Examination showed tender, movable mass in the right lower ab-

Fig. 6. Case V. Lipoma of the ascending colon intussuscepted into the transverse colon. Flat film shows a homogeneous soft tissue mass ("sausage") in the region of the transverse colon representing the intussuscepted portion of intestine. It is surrounded by air rings in the peripheral sheath. Air-filled small intestinal loops in the region usually occupied by the cecum and ascending colon.

domen, secondary anemia. Barium enema demonstrated a polypoid mass in the region of the ascending colon surrounded by thin parallel lines of barium. Cecum not filled; concave lower end of the filled part of the ascending colon. After evacuation the tip of the mass was in the transverse colon just beyond the hepatic flexure, ascending colon was shortened. Questionable filling of the appendix within the intussusception. *Operation:* Fungating, cauliflower mass in the cecum and beginning of the ascending colon. Histologically adenocarcinoma.

Case iv. E. C., female, aged thirty-eight, gave a history of four years' colicky pain lasting one minute two or three times daily, sometimes with vomiting. Almost constant pain for last four days, uncontrollable vomiting. *Roentgen examination:* Flat film showed sausage-shaped, homogeneous soft tissue mass in the right abdomen in the region of the cecum and ascending colon. Lower border of the soft tissue mass was concave. No barium examination was done. Immediate operation showed sessile polypoid adenocarcinoma intussuscepted into midportion of the transverse colon. The mass measured 4.5×4 cm. and projected 2 cm. into the lumen.

Fig. 7. Case v. Soft tissue demonstration of intussusception. Homogeneous soft tissue "sausage" corresponding to the intussuscepted gut is seen within the markedly dilated transverse colon (arrows). The ovoid lipoma is clearly seen at the head of the intussusception (double arrow). The surrounding sheath is filled with air (×). (Barium meal. Barium in the stomach, duodenum, jejunum and ileum. The barium has not yet reached the region of the intussusception.)

Fig. 8. Case v. Barium meal. Colon markedly intussuscepted (arrows), the tumor lying just to the left of the spine (double arrow). The degree of intussusception corresponds to that in Figures 6 and 7, the air in the surrounding sheath being partially replaced by barium.

II. Colocolic Intussusception

(a) Ascending colon intussuscepted into transverse colon.

Case v. M. H., male, aged sixty-two, complained of increasing constipation for two years. One year history of diffuse abdominal pain. Intermittent severe abdominal pain for three weeks. No palpable mass. *Roentgen examination:* Barium enema met with obstruction in the mid-transverse colon due to a smooth oval mass. Increase in the pressure of the enema was followed by a sound similar to that heard when uncorking a champagne bottle, while the mass gave way suddenly and moved into the ascending colon. After evacuation, the mass was again in the left side of the transverse colon. Barium cylinder surrounded the intussuscepted colon. Cecum and ascending colon were seen outside the intussusception, but they were shortened. Oral examination showed delay in the emptying time of the small intestine. Cecum and ascending colon were at times completely intussuscepted into the transverse colon; at other times the intussusception was reduced, and the egg-shaped mass was visible in the ascending colon. A flat film showed the transverse colon to be dilated and filled with a sausage-shaped homogeneous mass. The mass was surrounded in some places by an

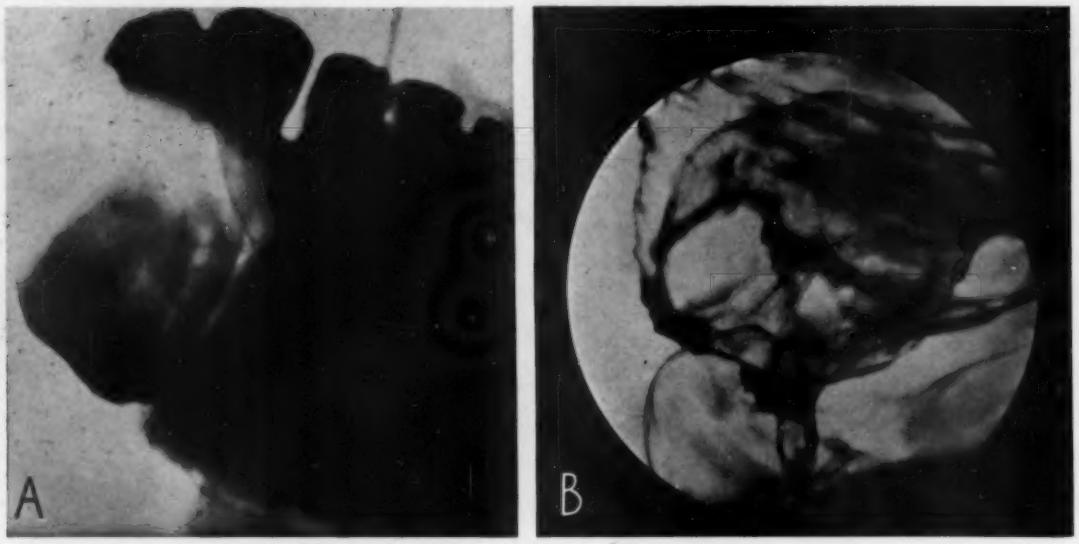

Fig. 9. Case v. *A*, spot film showing the tumor in the mid-transverse colon stopping the barium enema. *B*, the intussusception has been reduced by the enema, and the ovoid tumor is seen in the ascending colon (air insufflation).

air cylinder and in other places by spiral-shaped air lines. There were small intestinal loops visible in the region usually occupied by the right colon. *Diagnosis:* Intussuscepting tumor, probably benign. Original site of the tumor either in ascending colon, cecum or small intestine. *Operation:* Submucous lipoma of the ascending colon, 6 cm. distal to the ileocecal valve. Tumor measured 3.5×4.5 cm. and had a short pedicle. Tip of the tumor was necrotic.

Case vi. J. S., male, aged sixty-five, gave a history of four weeks' nausea and vomiting after eating. Increasing constipation, at the same time griping pain in the abdomen varying in location, followed by vomiting. Slight loss in weight. *Physical examination:* No mass pal-

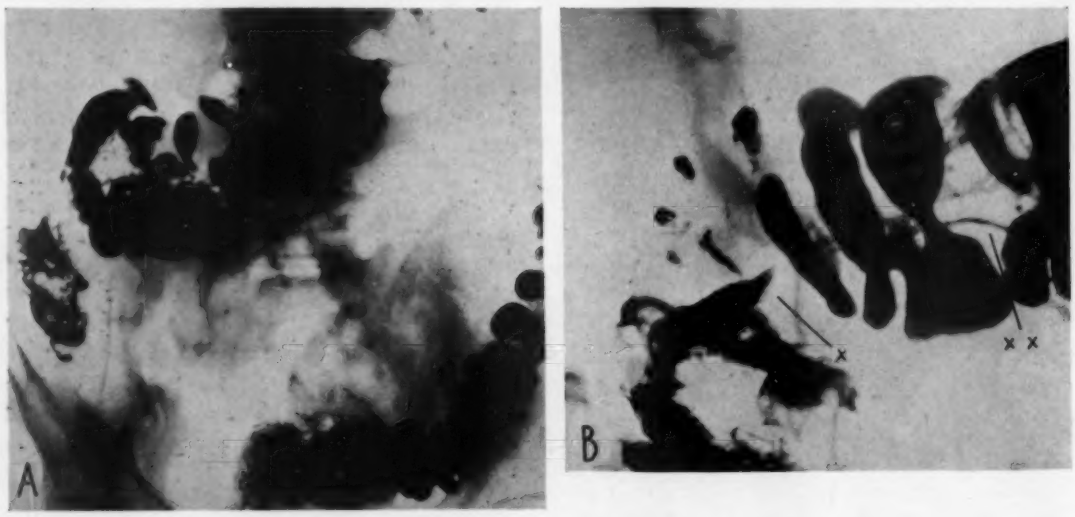

Fig. 10. Case v. *A*, after evacuation of the barium enema the colon is intussuscepted again. The tumor overlies the spine. Appendix, cecum and proximal ascending colon are not intussuscepted, in spite of the marked degree of intussusception present. *B*, region of the hepatic flexure. Barium meal. Cecum and ascending colon are completely intussuscepted. The longitudinal folds of the narrow central canal (×) are surrounded by barium rings in the surrounding sheath. Tumor at the head of the intussusception (××).

pable. Barium enema met with complete obstruction at the hepatic flexure, the obstructing end was round in shape with a notch in its center. A narrow streak of barium lying in parallel lines was seen within the distal end of the filled colon. After defecation a small amount of barium had passed into the ascending colon. *Roentgen diagnosis:* Polypoid tumor with evidence of intussusception. *Operation:* Tumor was found at hepatic flexure. Specimen showed ulcerating annular adenocarcinoma 10 cm. distal to the appendiceal orifice.

(b) Hepatic flexure intussuscepted into transverse colon.

Case vii. L. H., female, aged forty-nine. Eight months ago collapsed suddenly, unconscious for twenty minutes. During the last six months repeated abdominal attacks of cramps with visible "lump" going up and down her abdomen. Fainted five times. Physical examination showed a firm mass, size of baseball, freely movable and very tender. Stools positive for blood. Barium enema showed obstructing tumor in the middle of the transverse colon. The surface of the tumor was fairly smooth. Traces of barium surrounded the tumor and the intussuscepted gut beyond it in thin circular lines. The soft tissues beyond the filled area showed a broad, sausage-like, homogeneous shadow back to the region of the hepatic flexure surrounded by a few spiral-shaped air pouches. Shadows of the cecum and ascending colon were replaced by slightly dilated and gas-filled small intestine. There was some tenderness and sense of resistance in the right lower quadrant.

Fig. 11. Case vi. Annular adenocarcinoma of the ascending colon intussuscepted into the proximal transverse colon. The tumor itself is not visible in the overhanging pouches of the filled colon. Arrow indicates filling of the central canal. Barium enema examination. A similar picture of overhanging pouches has been reported in another case of intussusception of an annular tumor (Reiser and Gurniak).

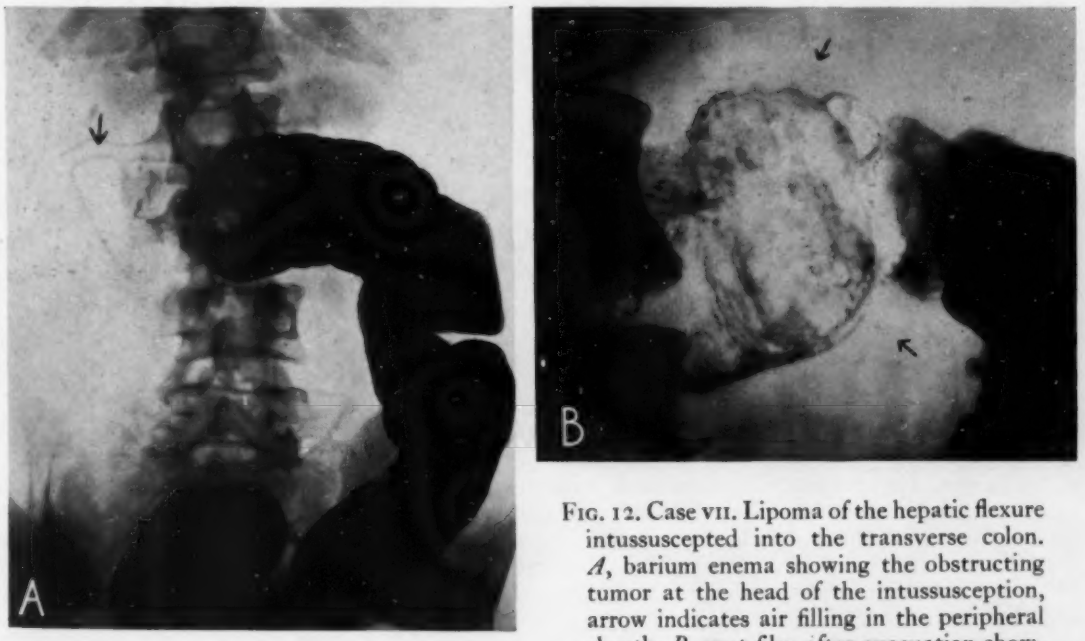

Fig. 12. Case vii. Lipoma of the hepatic flexure intussuscepted into the transverse colon. *A*, barium enema showing the obstructing tumor at the head of the intussusception, arrow indicates air filling in the peripheral sheath. *B*, spot film after evacuation showing the head of the intussusception (arrows). Small amount of barium in the peripheral sheath.

Fig. 13. Case IX. Tumor of the hepatic flexure invaginated into the transverse colon. Post-evacuation film after barium enema shows the polypoid tumor, filling of the peripheral sheath (arrow), as well as of the central canal (×).

Examiner made the diagnosis of an obstructing mass in the mid-transverse colon having the appearance of polypoid carcinoma, a diagnosis which is not borne out by restudy of the films as interpreted above. At operation the tumor was found at the hepatic flexure. The specimen showed a submucous lipoma 6×4×4 cm. with a broad pedicle. Necrosis of the distal third of the tumor.

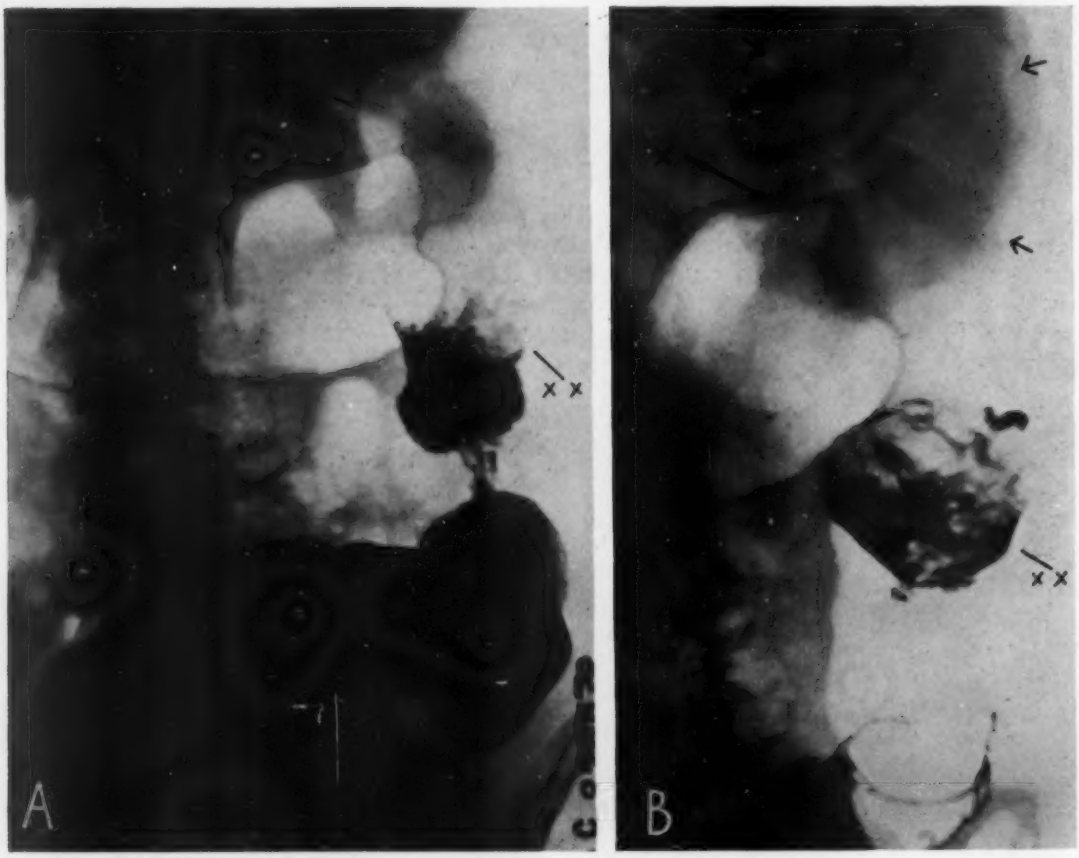

Fig. 14. Case X. Lipoma of the transverse colon intussuscepted into the descending colon. Barium enema examination meets with complete obstruction in the region of the ovoid tumor. Colon is dilated in the region of the tumor. The air-filled distended transverse colon becomes suddenly narrower proximal to the splenic flexure. *A* shows the air-filled narrow central canal in the region of the splenic flexure (×); tumor at (××). *B* shows the beak-shaped sudden narrowing of the air-filled transverse colon at the entrance of the intussusception (×), doughnut-shaped soft tissue mass (wall of the intussuscepted gut) surrounding the air-filled central canal (arrows). The distal surface of the tumor has remained coated with barium after evacuation of the enema (××).

Case viii. P. S., male, aged fifty-one, gave a history of two years of occasional lower abdominal pain; eight months of more severe paroxysms and bloody stools. Loss in weight. Hard, slightly tender mass in right upper quadrant. Barium enema examination showed obstructing mass in the proximal transverse colon partially surrounded by barium. Cap formation. After evacuation, the mass was better visualized within the surrounding sheath. Traces of barium in a narrow canal beyond the tumor (filling of the central canal). At operation the tumor was found in the region of the hepatic flexure. *Pathology:* Fungating mass 7×6 cm., adenocarcinoma.

Case ix. This case is included though no operative control was obtained. The roentgen appearance is so characteristic that there is no doubt about the diagnosis.

M. W., female, aged seventy-eight. Patient had been hospitalized ten years ago for weakness, anorexia, sharp mid-abdominal pains. Diagnosis of pernicious anemia was made. At that time, a defect near the hepatic flexure was found by barium enema and thought to be fecal material. Similar attacks occurred four of five times in the following eight months. Patient was then symptom-free except for occasionally blood-streaked stools until similar attacks returned three weeks before entry.

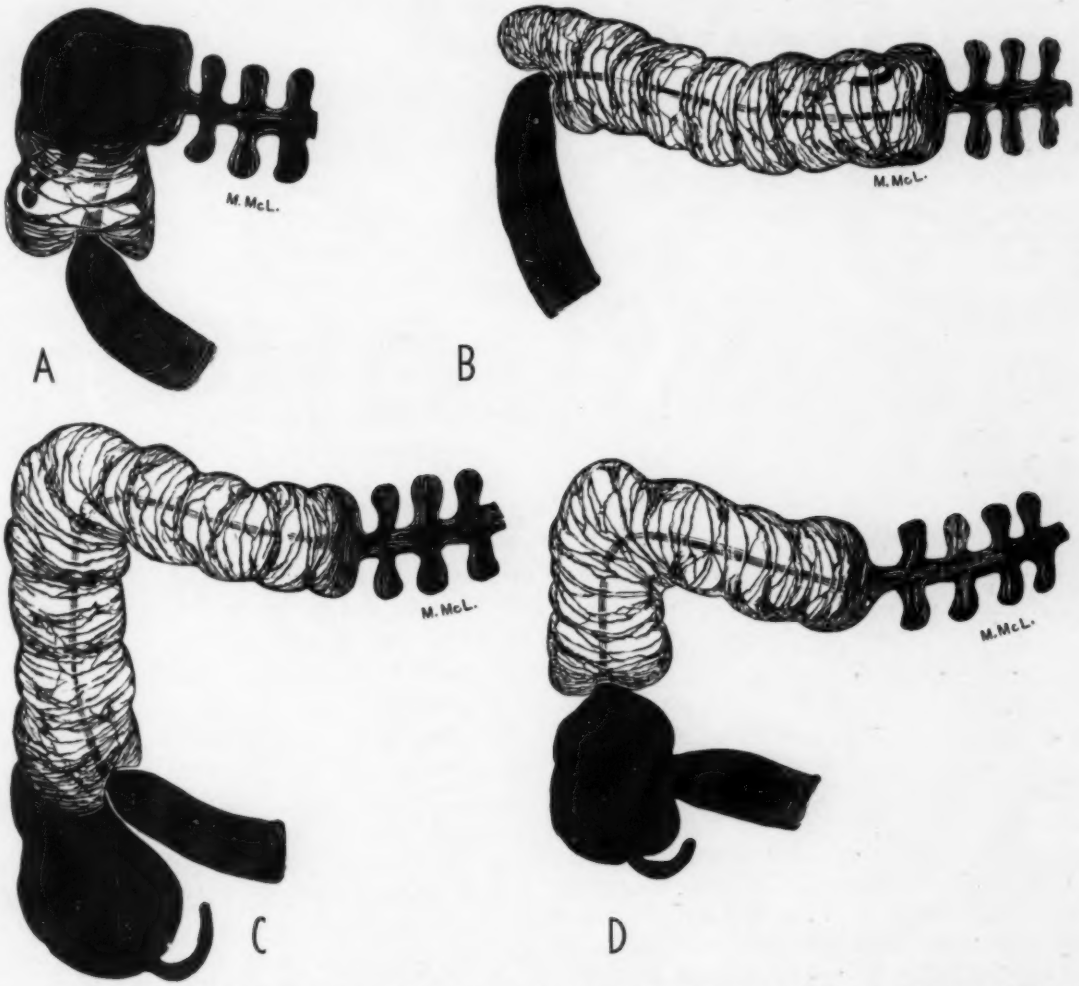

Fig. 15. Diagrams of different types of intussusception around the ileocecal valve. Position and filling of the appendix are particularly diagrammatical. Actually, filling of the intussuscepted appendix rarely occurs. *A*, moderate cecocolic (ileocecal) intussusception; *B*, extensive cecocolic (ileocecal) intussusception; *C*, ileocolic intussusception; *D*, colocolic intussusception.

Lately the pain came almost every day lasting four or five hours each time. Diarrhea with bright red blood. No weight loss in the past year. Physical examination showed sense of fullness in the right upper quadrant, but no definite mass. No evidence of pernicious anemia, but definite secondary anemia. Barium enema showed a polypoid filling defect about the size of a fist in the region of the hepatic flexure. After defecation the mass was seen to lie in the transverse colon close to the spine. Proximal to it was a cylinder of thin barium, the center of which showed longitudinal rugae (filling of central canal). The sleeve of the surrounding sheath was clearly visible at the entrance of the intussusception. Roentgen diagnosis was intussuscepted polypoid tumor near the hepatic flexure, probably malignant. No operation. Patient died one month later outside of the hospital. No autopsy.

(c) Transverse colon intussuscepted into descending colon.

Case x. M. R., female, aged fifty-four, gave a history of several years of attacks of weakness and gaseous eructations, aching in various parts of the body, numbness of the extremities, occasional vomiting. Entered hospital for vomiting and pain in the abdomen. Was considered neurotic until flat film of the abdomen showed a distended transverse colon. Barium enema examination showed block with cap formation about a well-rounded mass in the upper descending colon. The colon was widened in the region of the mass. The ascending and transverse colon were distended by air, the distal end of the transverse colon forming a cone-shaped narrowing like a bird's beak. There was a soft tissue mass between the air distended transverse colon and the obstructing mass in the descending colon. The soft tissue mass showed on some films a central narrow air-filled canal which was surrounded by a soft tissue cylinder producing a doughnut-like picture at the splenic flexure where it was seen end on. The distal end of the soft tissue mass was surrounded by a few circular air lines. Diagnosis was tumor originating in the transverse colon intussuscepting into the descending colon. At operation a lipoma with ulceration of its distal end was found in the mid-transverse colon.

(d) Sigmoid intussuscepted into sigmoid.

Case xi. G. T., male, aged sixty, gave a history of one month of pain in the abdomen, never very severe. Abdomen distended. Flat film showed marked distention of the air-filled proximal colon. The barium enema examination demonstrated complete block with cap formation in the sigmoid. After evacuation partial sheath filling around the mass was seen. Roentgen diagnosis was carcinoma of sigmoid with total obstruction. At operation a fungating non-ulcerated mass $4 \times 5 \times 3$ cm. with central fibroid pedicle was found in the sigmoid. Histologically, colloid adenocarcinoma.

SUMMARY

(1) Eleven cases of intussuscepting tumors of the colon are reported.

(2) The roentgen symptomatology of colonic intussusception is discussed.

A large variety of roentgen signs have been described in the literature. They can all be fairly easily explained by the anatomical process: a narrow central canal is separated from a shallow, hollow peripheral sheath by a thick soft tissue mass, represented by the intussuscepted mesentery and by the tissue of the wall of the in- and the outgoing portion of the intussuscepted intestine. The variety of roentgen pictures is produced essentially by differences in the degree of filling of the central canal and the peripheral sheath. They may contain barium or air ("spontaneous" air filling, or air insufflation). If the pattern of the central canal is visible, it usually shows longitudinal folds while the surrounding peripheral sheath has transverse folding.

(3) Particular stress is laid upon the changes seen in the soft tissues as they are visible on films without barium examination (flat films). The great majority of cases with intussusception show definite variations from normal at such an examination, and at times a positive diagnosis of intussusception can be made from the flat film. In many instances a picture characteristic of intussusception can be obtained.

(4) If in complete obstruction the intussusception itself is poorly outlined, a study of the soft tissue shadow proximal to the obstruction may demonstrate intussusception as the cause of obstruction.

(5) Intussusception in adults is not al-

ways an acute dramatic event, but may produce the picture of a chronic intermittent abdominal disease.

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ROENTGENOLOGICAL ASPECTS OF THE CONGENITALLY SMALL COLON AND OF INTESTINAL OCCLUSIONS

WITH REPORT OF FIVE CASES

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THE occurrence of a congenitally small colon is usually secondary to an atresia or occlusion of the intestinal tract proximal to the underdeveloped bowel. For this reason, a discussion of the congenitally small colon or microcolon necessarily involves a consideration of congenital obstruction of the small and large intestines. Only 2 cases of congenital microcolon have been reported in the roentgenological literature (Stephenson, 1936). We have encountered the rather striking roentgenographic finding of an exceedingly narrow colon in 5 infants presenting symptoms of intestinal obstruction at the University of Nebraska Hospital and the Nebraska Methodist Hospital during the past four years. In the following presentation, the history of the subject will be reviewed, our cases briefly presented and the differential diagnosis, etiology and prognosis will be discussed.

About 500 cases of congenital obstruction of the intestinal tract occurring below the pylorus and above the rectum have been reported in the general medical literature. Calder is quoted by Poynter as having described the first case in 1733, a congenital occlusion of the duodenum. Theremin reviewed the literature and case reports up to 1877. Kuliga (1903) tabulated the records on 189 cases and endeavored to analyze them from the standpoint of etiology. Kreuter (1905) reviewed 313 cases of congenital obstruction of the gastrointestinal tract. Spriggs (1912) presented a classic review of the subject covering 324 case reports and 24 additional cases with careful anatomical studies. Davis and Poynter (1922) reviewed the literature covering 392 cases. Ladd (1933) reviewed the literature and added 60 additional cases with an analysis of the results of surgical treatment.

Greig (1925) reviewed 28 cases of microcolon in which the lumina of the bowel did not appear to be definitely obliterated. Heckel and Apfelbach (1927), on the other hand, reviewed 30 cases of atresia of the colon. Many cases of congenital obstruction of the intestinal tract are in the literature but the incompleteness of some reports and the lack of convincing study in others make it impossible to establish the true frequency of microcolon in cases of congenital occlusion of the intestines. It is our belief that the occurrence of microcolon distal to intestinal atresia is much more common than is suggested in reports of operative findings, where lack of time and poor exposure leave much to be taken for granted.

The reported incidence of congenital occlusion or atresia of the intestinal tract varies greatly. Cole found 40 cases among 370,000 births or about 1 case of occlusion per 9,288 infants. Our own experience suggests a higher incidence, there being 2 cases among 4,000 hospital births with 3 cases drawn from the surrounding territory. The relative frequency of intestinal occlusion among the various congenital obstructions of the gastrointestinal tract is indicated in the tabulations of Kreuter (1905): esophagus 111 cases, stomach 8 cases, duodenum 58 cases, jejunum and ileum 103 cases and colon 33 cases. Our own small series shows the following distribution: esophagus 3 cases, cardia 1 case, pylorus 1 case, duodenum 2 cases, jejunum and ileum 5 cases, colon 1 case and rectum 3 cases. It then

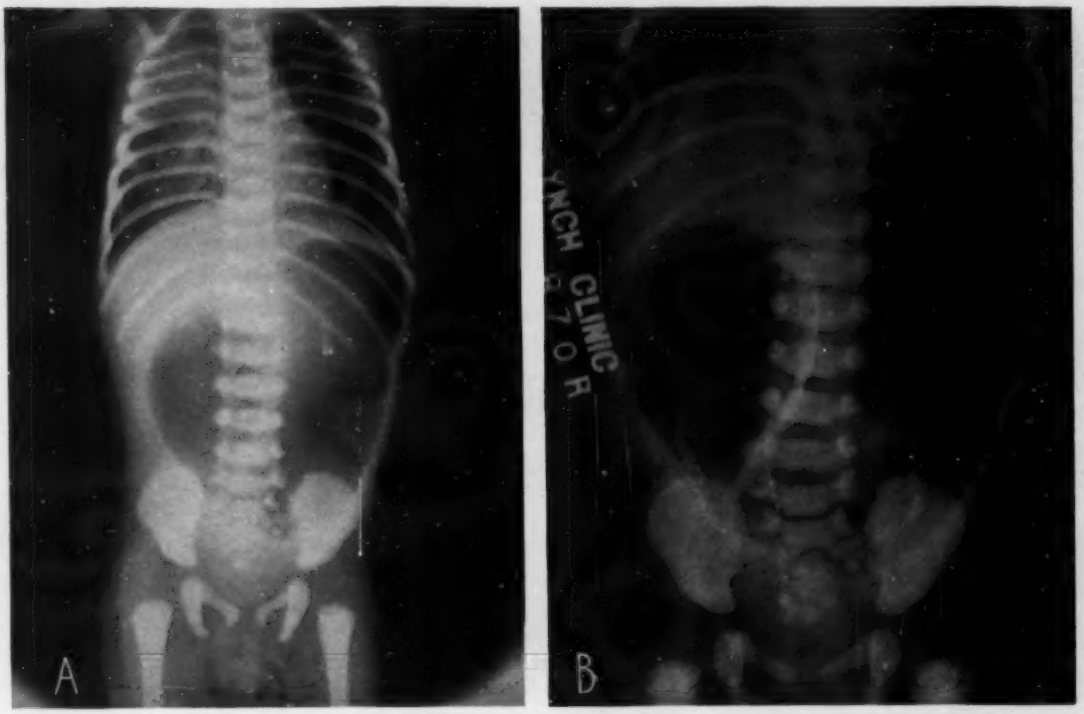

Fig. 1. Case 1. *A*, obstruction in the second portion of the duodenum showing enormous distention of the stomach with no gas in the distal bowel. *B*, postoperative study showing persistent distention of the stomach. Oral barium has passed into the colon which is narrow.

appears that over half of the congenital obstructions of the gastrointestinal tract involve the small intestine or colon.

CASE REPORTS

The following case showed an atresia of the duodenum near the ampulla giving obstruction in both the gastrointestinal and biliary tracts. The colon was narrow. The preoperative plain roentgenogram of the abdomen rather strikingly portrays the characteristic roentgenological findings of high duodenal obstruction.

Case 1. Baby girl L. C., aged six days. Case of Dr. J. H. Lynch seen in consultation. Seven siblings are living and well. Baby appeared healthy at birth. Distention, vomiting and jaundice were noted after forty-eight hours. At entry, jaundice, moderate dehydration and visible peristalsis in the upper abdomen were evident. No movement of the bowels had occurred spontaneously even after castor oil, although meconium was expelled following an enema. Subcutaneous glucose and normal saline had been given to combat dehydration.

A preliminary roentgenogram of the abdomen (Fig. 1, *A*) showed gross dilatation of the stomach and probably of the proximal duodenum with gas filling nearly the entire abdomen. No gas shadows were discerned further in the small intestine or colon.

Operation revealed an enormous dilatation of the stomach and upper portion of the duodenum. There appeared to be an atresia of the duodenum in its second portion at about the level of the entry of the common duct. The distal bowel was thought to be normal. A posterior gastroenterostomy was done. Barium given by mouth appeared to pass through the small intestine into a relatively small colon (Fig. 1, *B*) following operation. Post-mortem examination confirmed the duodenal atresia and showed the small intestine to be of slightly less than average size although the colon was narrow, being about 8 or 10 mm. in diameter. Patency of the gastrointestinal tract had been established at operation.

The second case is an example of complete atresia of the upper ileum with unusually early onset of symptoms of ob-

Fig. 2. Case II. Complete atresia of the upper ileum showing gaseous distention of the small intestine and microcolon.

obstruction with vomiting. The colon was very narrow. Roentgenographic findings are quite characteristic of obstruction in the mid or lower portion of the small intestine.

Case II. Baby girl L. W., newborn (Univ. Nebr. Hosp. 49570). At birth the baby appeared essentially normal. Slight distention of the abdomen was noted soon after birth, and greenish fluid was vomited about two hours after birth. Vomiting of a greenish fluid recurred with increasing frequency and the abdomen became more distended. Peristalsis was active. No meconium was passed from the anus.

Roentgenographic study of the abdomen (Fig. 2) made at twenty-four hours of age showed a marked distention of the intestines to a diameter of 3 to 6 cm., without enlargement of the gas distended stomach. Administration of a barium enema showed the colon to be patent, being 4 to 6 mm. in diameter except through the rectal ampulla and sigmoid in

Fig. 3. Case III. Congenital obstruction of the small intestine with generalized narrowing of the colon.

which the lumen was 6 to 10 mm. in size. Operation revealed a complete atresia through the upper ileum with interruption in continuity of the gut over a segment about 2 cm. in length. The ileum above this defect was enlarged to a diameter of 4 or 5 cm. The ileum below the defect was collapsed. A cyst-like sac about 2.5 cm. in diameter filled with greenish fluid appeared free in the mesentery between the blind ends of the interrupted ileum. The colon was collapsed to a cord-like structure 4 to 6 mm. in size. An anastomosis was done joining the dilated ileum to the sigmoid with insertion of a catheter by way of the rectum through the anastomosis into the ileum. The anastomosis functioned well but death occurred two days later.

The third case is similar to the second, presenting the clinical and roentgenological findings of an obstruction in the ileum associated with a microcolon.

Case III. Baby girl H., newborn (Nebr. Meth. Hosp. 116299, Dr. Taylor). Baby weighed 6¼ lb. at birth and appeared healthy. After about twenty hours the abdomen became distended, with vomiting of dark green fluid and of all food taken. No meconium or other material was passed from the rectum. Progressive distention and dehydration followed although

normal saline was given by rectum and 20 per cent glucose was administered by mouth. Operation was dismissed as being of no value.

Preliminary roentgenographic study of the abdomen showed gross distention of the intestines to a diameter of 4 to 5 cm. (Fig. 3). Administration of a barium enema showed the rectum to be 8 to 10 mm. in size with the colon narrowed to a diameter of 3 to 5 mm. in width. A further study twenty-four hours later showed barium remaining in the colon. Oral administration of barium showed no apparent enlargement of the stomach, although only a trace of barium had passed the pylorus after seven hours. The extensive distention of the small intestine shows that the primary obstruction was situated below the pylorus, probably in the ileum.

The fourth case presented the clinical picture of multiple, partial obstructions of the small intestine. The general roentgenographic appearance was that of obstruction of the small intestine, similar to Cases II, III, and IV. The colon was slightly less narrow than in the other cases.

Case IV. Baby boy R. M., age three weeks (Nebr. Meth. Hosp. 113261, Drs. Weigand and Kennedy). Dr. Kennedy had previously attended a brother born with an imperforate anus. The baby weighed 8 lb. at birth, appeared normal and took formula for two days, followed by refusal of food and later by forceful vomiting, loose greenish stools and loss of weight. Examination showed a dehydrated athreptic infant with distention of the abdomen. Temperature was 99 to 101° F., white blood count was 44,600. Hartman's solution was given by mouth, intramuscularly and intravenously.

Plain roentgenographic study of the abdomen suggested fluid in the peritoneal cavity and showed loops of small intestine dilated to 4 to 5 cm. in size (Fig. 4, *A*). Barium introduced into the stomach through an esophageal catheter showed practically no progress into the duodenum and jejunum after two hours. Retention of a barium enema was made possible by passing a catheter up the colon into its transverse portion (Fig. 4, *B*). The colon was generally small, being about 8 mm. in diameter. Barium was recovered from the stomach and stool for four days after administration.

Operation by Dr. C. R. Kennedy revealed a relative narrowing at the pylorus, another constriction in the jejunum and a generalized marked narrowing of the entire terminal ileum and colon to about the size of a leadpencil.

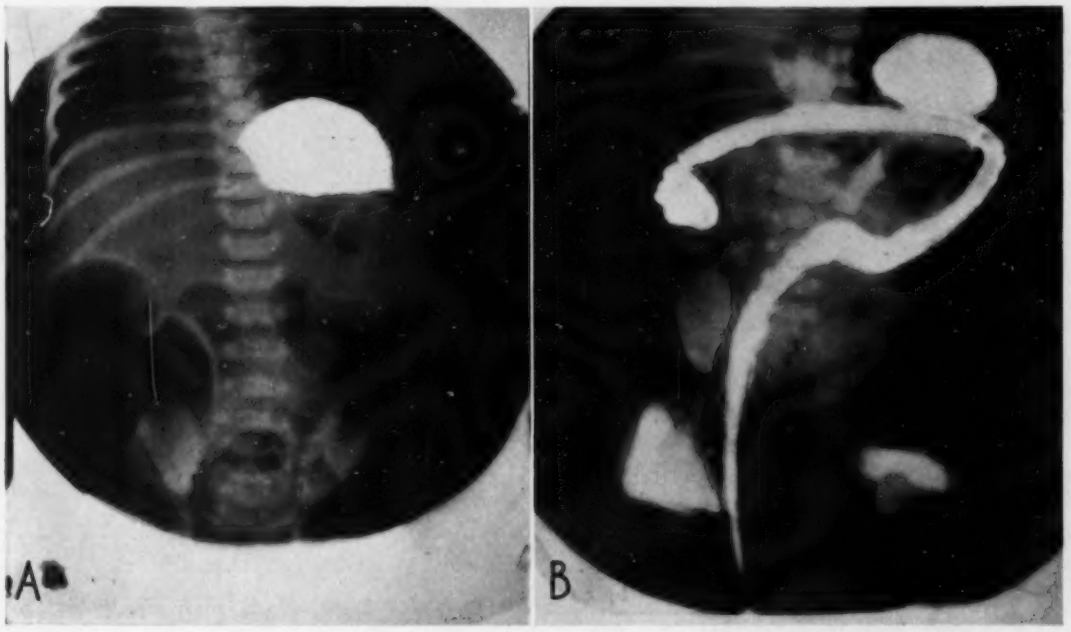

Fig. 4. Case IV. *A*, incomplete multiple obstruction of the small intestine showing pocketing of gas in the small intestine. *B*, colon relatively small, secondary to stenosis of the small intestine, nondescent of the cecum.

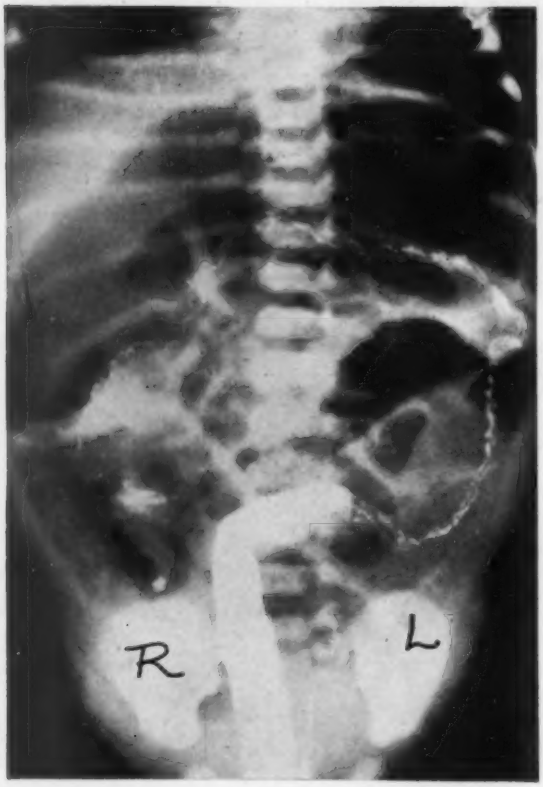

Fig. 5. Case v. Congenital stenosis of the terminal ileum with inspissated meconium showing marked distention of the small intestine and a microcolon.

The ileum above the stenosis was dilated to about 3 to 5 cm. in size. An ileostomy was done by placing a catheter into the distended loop. Death occurred four days later.

Obstruction in the following case was reported as due to inspissation of meconium in the terminal ileum and cecum. The roentgenographic findings were likewise those of obstruction in the ileum with a microcolon.

Case v. Baby girl M. H., newborn (Univ. Nebr. Hosp. 39450). Baby appeared healthy at birth and nursed normally for two days. Distention of the abdomen gradually appeared, beginning after twenty-four hours, and vomiting of greenish black material occurred on the third day. No meconium was passed from the anus. Rectal examination showed no obstruction; slight bleeding followed.

Roentgenographic study of the abdomen showed gross, extensive dilatation of the small intestines to a diameter of 3 to 5 cm. The Magenblase was not definitely enlarged. A barium enema demonstrated patency of the colon although its lumen was greatly narrowed, being 3 to 4 mm. in size, except through the rectum, in which the ampulla was 10 to 15 mm. in size (Fig. 5).

Operation by Dr. C. R. Kennedy showed marked distention of the small bowel and contraction of the colon to a small cord about the size of a leadpencil. An ileostomy was done by introduction of a catheter into the dilated ileum. Death occurred twelve hours later.

Autopsy revealed marked dilatation of several loops of intestine and evidence of a peritonitis. The lower mid-ileum was distended to 4 or 5 cm. in size over a section about 60 cm. in length with marked constriction in a segment about 2 cm. in length just distal to the dilatation. The lumen of the bowel immediately above and through the narrowed portion appeared to be patent throughout, but was occluded by heavy, brownish sticky material which was inspissated meconium. Fibrinous adhesions surrounded the lower end of the dilated segment of ileum. This reaction was interpreted as secondary to a stercoral ulcer in the wall of the gut, with a peritonitis which very probably had preceded the operation. No atresia or occluding bands were found. The colon was generally small, being 4 to 8 mm. in diameter. No cause for obstruction was discerned other than the inspissated meconium.

EMBRYOLOGY

The important events in the development of the intestinal tract occur between the fifth and twelfth weeks. Prior to the fifth week the gut presents a round lumen lined with epithelium. According to Lewis, the epithelium through the duodenum proliferates irregularly with obliteration of the lumen, as shown in Figure 6 copied from the presentation of Lewis. Similar irregular proliferations occur at various levels through the small intestine. Vacuolation gradually occurs with coalescence of spaces until the lumen is again patent and clear at about the twelfth week.

During the period from the fifth to the tenth week the gut is extruded into the base of the umbilical cord. During the process of return into the abdominal cavity,

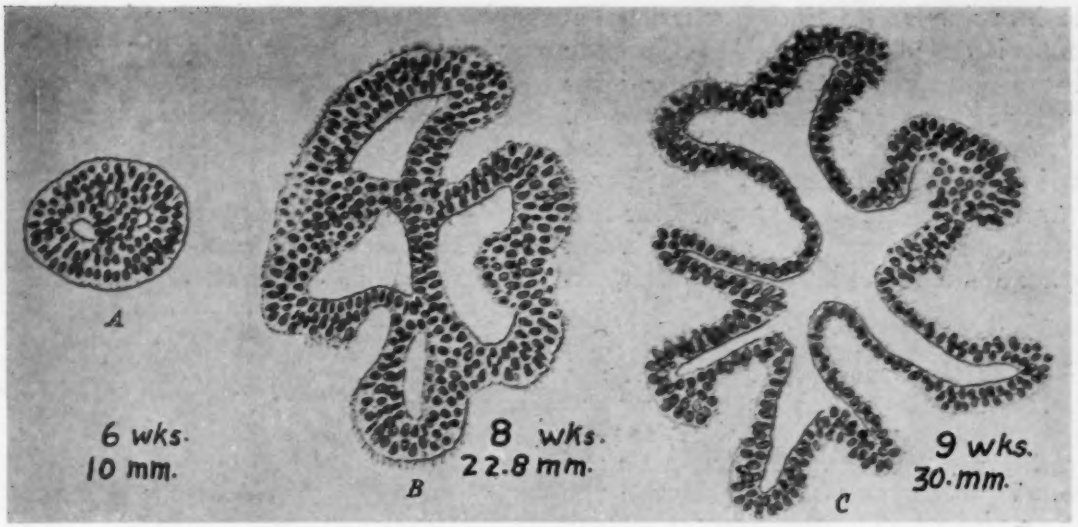

Fig. 6. Cross section of duodenum showing proliferation of cells occluding the lumen followed by vacuolization and re-establishment of the lumen (Lewis in Keibel and Mall).

the intestines undergo rotation about the superior mesenteric artery to attain their adult position. The mesentery of the intestine gradually becomes fused with the parietal peritoneum of the posterior abdominal wall.

PATHOLOGY

Congenital obstruction of the intestine may result from intrinsic occlusion, showing atresia or stenosis of the lumen, or it may result from narrowing of the lumen due to extrinsic pressure. The latter may result from faulty rotation of the intestines or peritoneal bands.

Various theories have been offered to explain the intrinsic obstruction (Hahn). Simpson (1838) attributed various intra-abdominal abnormalities, including intestinal occlusion to peritonitis occurring in the fetus prior to birth. Bland-Sutton (quoted by Greig) suggested that atresia resulted from unusual tension upon the intestine during the embryonic process of extrusion into and retraction from the neck of the umbilical cord. Poynter (Davis and Poynter) showed sclerosis and occlusion of the nutrient arteries supplying the various sites of multiple atresia of the small intestine in the case shown in Figure 7, previously reported from this institution. Greig advanced the hypothesis that narrowing of the ileum or colon without obliteration of lumen was the result of a tonic imbalance in the regional autonomic nervous system during development. Preponderant parasympathetic influence was held causative of an achalasia or lack of relaxation producing what he would term a "true microcolon," as in Case iv. Inspissated meconium has been described as a primary cause of obstruction (Farber) and it was the only cause of obstruction described in our Case v. It is our own belief that both the microcolon and the inspissation of meconium are secondary to preceding obstruction, rather than primary causes of obstruction.

It has been explained under "embryology" that the duodenum and various sections of the small intestine show a phase between the fifth to tenth weeks when the lumina are normally obliterated by proliferation of cells. It is therefore most logical to explain atresia or stenosis as due to lack of, or incompleteness of canalization (Kreuter). Atresia results from persistence of the solid state and fetal size in more severe cases. Stenosis results from considerable delay in clearing of the lumen or from a persistent but perforated septum of tissue.

The intestine above the obstruction becomes distended. The intestine below the point of obstruction remains collapsed due to a lack of entering contents. In case of stenosis the bowel below the obstruction remains small but not as small as in case of atresia (compare Case IV and Case III). It would be our hypothesis that stasis and inspissation of meconium always occur secondary to some preceding atresia, as in the case described by Hughes. The atresia may not be evident at the time of birth due to subsequent canalization. We would also believe that the true microcolon of Greig with patent intestinal lumen is also secondary to a delayed canalization of the ileocecal valve or terminal ileum.

The familial occurrence of congenital

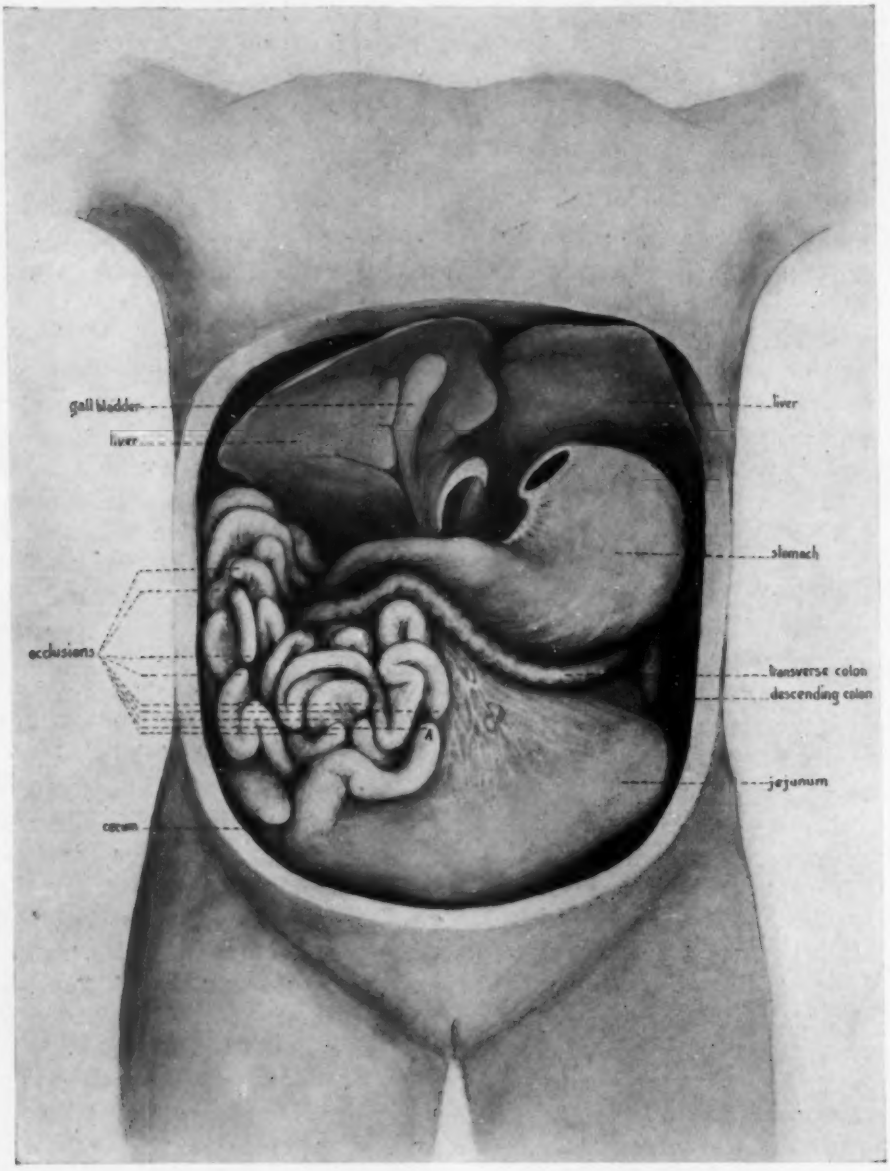

Fig. 7. Case of multiple occlusions of the small intestine, reported by Davis and Poynter. The widely dilated jejunum occupies the left and inferior regions; this contracts suddenly and ends in a blind tube at *A*. The narrow distal small intestine with multiple occlusions is on the right. The contracted transverse colon with no great omentum lies just below the stomach.

obstruction was noted in Case IV and was strikingly absent in Case I. Fennel and Walker have also noted the familial occurrence of congenital atresia.

CLINICAL MANIFESTATIONS

The above reports of case histories substantiate the following clinical manifestations of congenital obstruction of the intestinal tract. The newborn infant with congenital obstruction of the gastrointestinal tract appears entirely normal at birth. Inspection reveals the anus to be perforate. No meconium is passed by rectum unless the obstruction is incomplete, as in Case IV, or unless the obstruction is above the entry of the common bile duct into the duodenum, as in Case I. We have noted passage of meconium in a second case of duodenal atresia. The infant usually nurses normally (exception, Case II) in contrast with the baby having an atresia of the esophagus who chokes and regurgitates. Increasing abdominal distention and persistent vomiting first suggest serious trouble.

In general, vomiting is first noted, although if the obstruction is low, progressive distention may be the initial symptom. Vomiting occurs after an interval of time which in general becomes shortened with the completeness of obstruction and as the site of obstruction occurs higher in the gastrointestinal tract. In case the vomitus is stained with bile, it is very probable that the obstruction is below the entry of the common duct into the duodenum. Swallowing of meconium stained amniotic fluid may, however, stain the initial vomitus (Cockayne). Visible peristalsis is most evident in duodenal obstruction (Case I), due to vigor of gastric contractions. Peristalsis may also be visible in obstructions situated lower in the small intestine.

Persistent vomiting leads to progressive dehydration and loss of weight. A low fever and some elevation of the white blood count may develop, as in Case IV. Occasionally, the intestine may become ruptured near the site of obstruction by inspissated meconium with development of peritonitis, as in Case V. Toxemia develops and death follows according to the usual course of intestinal obstruction, unless operative intervention is successful.

ROENTGENOGRAPHIC FINDINGS

The roentgenological findings in various congenital obstructions of the gastrointestinal tract have been classically described by Kerley and LeWald, Vogt, Wangensteen, and many other authors. Stephenson has described a case of generalized microcolon comparable to Case IV in our series. His case showed distention of the small intestines with gas, a generally narrowed colon lacking in haustrations and incomplete rotation with lack of descent of the cecum (Peirce). Our cases showed varying degrees of incomplete descent of the cecum.

The value of the plain roentgenogram of the abdomen in the diagnosis of intestinal obstruction was first noted by Schwarz in 1911, and has been amplified by Ochsner and Granger, and others. Use of a horizontally projected beam with the infant supported upright is advised in order to clearly demonstrate gas above the fluid levels. Our studies were made with a vertical beam and demonstrate the accumulated gas because of its very large amount. Bouslog points out that the jejunum of the infant fails to show the "feathery" appearance of the adult types, and the distended jejunum in our cases has failed to show the "herringbone" pattern evident in the distended adult jejunum by the taut plicae circulares. This uniformity of small intestinal pattern makes exact differentiation of the level of obstruction on the basis of individual pattern unreliable. On the other hand, the roentgenologist can be entirely certain that there is no gas below the level of a complete atresia and that is a diagnostic aid which is lacking in all other levels of intestinal obstruction. This is well shown in Case I. Case III was diagnosed clinically as a pyloric stenosis but it is known from the roentgenogram that the obstruction is probably in the ileum due to the numerous

loops of gas distended small bowel. In retrospect (Case v), we believe that oral administration of barium is unnecessary and probably contraindicated, due to the possibility of further obstruction by lodgment of barium in a stenotic zone.

Administration of a barium enema carries only a very slight hazard, in our opinion, and is frequently helpful. Inspissation of barium can be lessened by immediately following its administration with an equal quantity of mineral oil and the continued daily use of mineral oil until the barium has been passed. A barium enema is of aid in establishing patency or occlusion of the colon, and it also aids the surgeon in some cases by portraying the gut available for anastomosis. It is our belief that the colon is nearly always narrow below a complete atresia. However, there are numerous case reports in the literature which appear to dispute this statement. The colon is somewhat larger in size in cases of incomplete obstruction, such as Case iv, or in cases where obstruction develops somewhat later in fetal life due to faulty rotation (Dott, Gardner and Hart), a transduodenal band, or a cysticocolic ligament (Greig). We are unfamiliar with any definite criteria to aid the roentgenologist in establishing whether the obstruction is due to faulty rotation or intraluminary occlusion. We have noted 2 cases of partial obstruction in the prepyloric region of children due to a persistent cysticocolic ligament in whom the pressure defect of the band could be discerned across the barium-filled pyloric antrum.

PROGNOSIS AND TREATMENT

Successful operation for congenital obstruction was first reported by Fockens in 1911, and since then other successes have been reported by Sweet and Robertson, Rotter, Gaub and Ladd, and by a few others. The outcome of the untreated case of complete obstruction is certainly fatal.

Accuracy of diagnosis before considering surgery is important. Exclusion of a partial stenosis of the rectum which can be manually dilated is essential. A relative stenosis at the rectosigmoidal junction with prolapse giving complete obstruction in a newborn infant may be encountered. We recently reduced an obstructing prolapse in this region by pulsating pressure exerted through a barium enema by means of the syringe bulb. Congenital intussusception has been reported by Gelston and Sappington.

Having established the presence of congenital obstruction of the intestine, prognosis will depend upon the general condition of the patient, the level of the obstruction and whether it is due to an intraluminal defect or to external pressure caused by faulty rotation or bands. By far the most favorable site of obstruction is the duodenum. In Ladd's series of 60 operated cases, 26 had duodenal obstruction and of these 13 recovered. When dealing with a case of duodenal atresia, he advises a duodenojejunostomy to avoid the duodenal stasis which follows a gastroenterostomy. In case the obstruction is due to a faulty rotation, the volvulus must be reduced, constricting peritoneal bands severed and any attachment of the colon or ileum to the right of the duodenum freed to prevent recurrence of volvulus. The prognosis is poor when the obstruction involves the jejunum or ileum. Of Ladd's 34 operated cases of obstruction involving the jejunum or ileum, only 4 recovered, obstruction being due to faulty rotation in 1 and due to atresia in 3 of the cured cases. A primary anastomosis rather than an ileostomy is advised by Ladd in cases of atresia. The collapsed bowel gradually becomes normal in size with use after anastomosis. Dehydration and ketosis require preoperative and postoperative administration of fluid, salts and glucose. Early diagnosis and prompt surgical treatment are important as in all cases of intestinal obstruction.

SUMMARY

1. The general literature on the subject of congenital occlusion of the small intestine and of microcolon are reviewed.

2. The clinical manifestations and roentgenographic findings in five cases of congenital microcolon are presented.

3. Microcolon is interpreted as being secondary to an atresia or stenosis of the bowel proximal to the narrowed colon; the more complete the obstruction, the smaller the colon.

4. Atresia and stenosis are considered to result from an arrest or delay in normal canalization of the intestinal lumen which usually becomes partially occluded by irregular proliferation of cells between the fifth and tenth weeks of embryonic life, according to Lewis.

5. The site of occlusion in complete congenital obstruction of the small intestine can usually be determined by the plain film. No oral barium is given. Barium enema with oil is a safe and often helpful diagnostic procedure.

6. The prognosis with proper surgical repair is good in congenital obstructions of the duodenum and very poor in obstructions of the jejunum and ileum unless the latter are due to peritoneal bands or volvulus.

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ACUTE TRANSIENT INTESTINAL ATONY*

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THIS report is concerned with a peculiar disorder of the intestinal tract which has not yet been described. In a number of patients referred to this department for roentgen examination, because of some clinically obscure abdominal condition, an excessive enlargement of the colon was found roentgenologically and was reported as megacolon. For reasons of their own, the clinicians did not accept this diagnosis, and the examination was therefore repeated after three or four days. On this occasion, as well as on numerous other re-examinations made in the course of the subsequent twenty-eight months, the colon was found to be perfectly normal. In 1 case no clinical diagnosis could be made; in 2 others, that of mesenteric thrombosis was adopted on clinical grounds; in 3 cases, the presence of renal calculi was demonstrated by roentgen and urological examinations. Any technical mistake, that might supposedly be responsible for the singular enlargement, is excluded by the fact that the technique used was identical in all cases, and that during the stage of enlargement the colon admitted more than 2 liters of the opaque fluid, whereas afterward less than 1 liter was enough to fill the colon completely. Furthermore, in all of these cases, spontaneous contraction failed to evacuate the colon as long as the state of enlargement lasted, but emptied it normally on subsequent examination.

As for the technique used, it should be noted that the patient was always rotated continuously during administration of the enema, in order to prevent artificial dilatation of the sigmoid by the formation of a sharp bend at its junction with the descending colon.

In the cases above mentioned, most of the clinical symptoms and signs were variable and inconstant, but one symptom was present in all of them, namely, acute and severe colicky pain. Now it is held on theoretic grounds, that severe pain may cause increased adrenal secretion, thus inducing intestinal dilatation by the action of adrenal substances upon the digestive tract; but in our many examinations of patients suffering from severe pain (e.g., from sciatica, lumbago, metastasis in the spine, herpes zoster, neuritis, fractures, stenocardia, etc.) no intestinal dilatation whatever was seen roentgenologically. On the other hand, marked dilatation was found in patients suffering from acute colicky pain due to renal calculi, and, less commonly, as an accompaniment of disease of the gallbladder. In one instance, dilatation was observed in the presence of an acute duodenal ulcer, and disappeared when the niche was no longer demonstrable. We are driven therefore to the conclusion that pain is not in itself responsible for the dilatation now under discussion, but that diseases associated with severe colic may be correlated with such dilatation.

If one studies plain roentgenograms of the urinary tract taken before, during, and after attacks of renal colic, one finds that gas is often absent before and after the attack, whereas it is present during the attack in such large amount that it usually fills the colon and seems to distend it; less regularly, parts of the small intestine, recognizable by their valvulae conniventes, may also be found distended by large quantities of gas. If, during such an attack of colic, one examines the colon with the help of a barium enema, one will find a very marked dilatation of the whole colon, and spontaneous contraction will often have no effect, so that the colon appears,

* Read at the Fifth International Congress of Radiology, Chicago, Ill., Sept. 13–17, 1937.

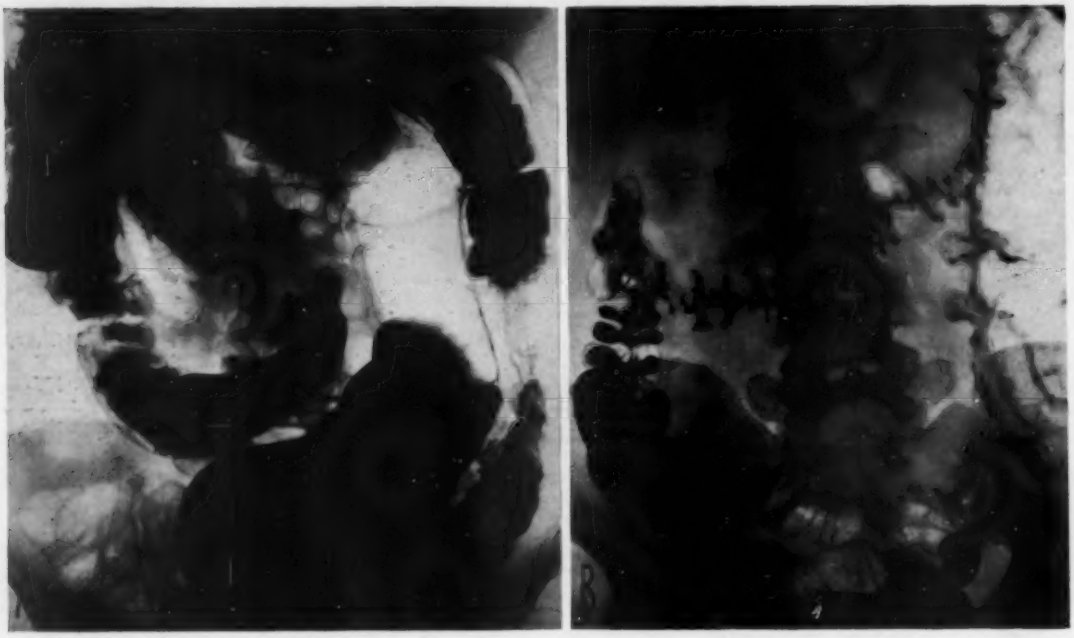

Fig. 1. Excessive dilatation and elongation of the entire colon, *A;* roentgenogram taken *after* attempted evacuation. Twelve days later, *B*, the colon is normal in caliber and length. Identical technique in both examinations. A case of severe pain due to acute duodenal ulcer. No recurrence of the colonic enlargement during the subsequent twenty-eight months.

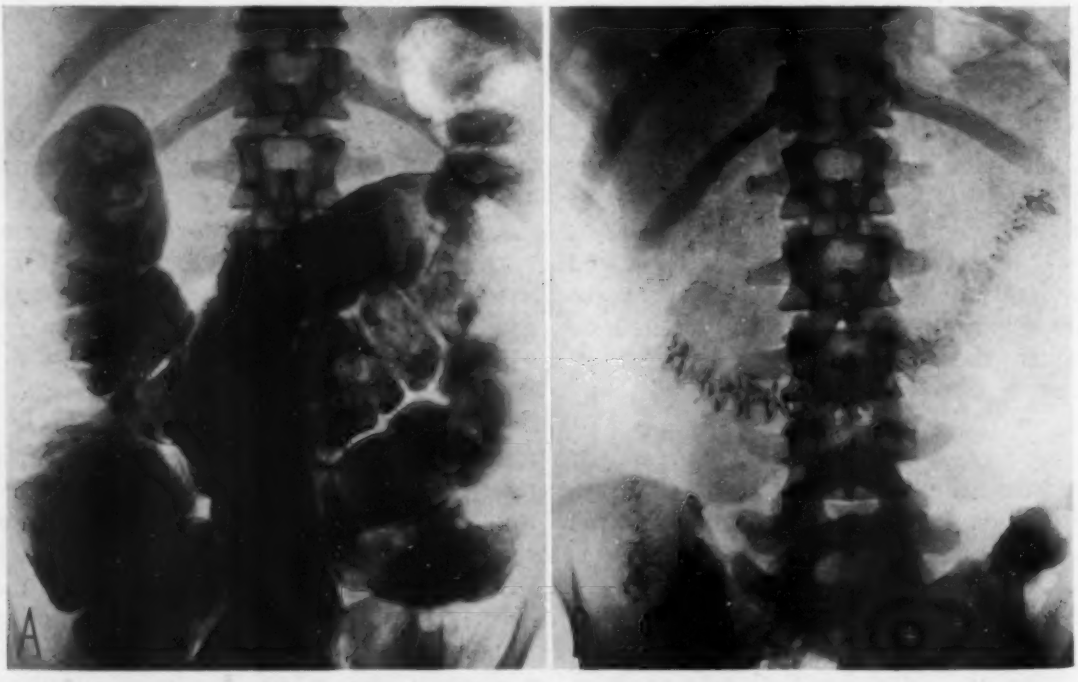

Fig. 2. Barium enema during, *A*, and two days after, *B*, renal colic. Technique identical in both examinations. Both roentgenograms taken *after* spontaneous evacuation. Although, in *A*, some of the barium enema was expelled, the colon failed to contract.

after such a contraction, to be of the same caliber and length as before it. Similar observations can be made occasionally during the persistence of colicky pain due to disease of the gallbladder. As a rule, this kind of intestinal dilatation disappears within a day or two after the pain has subsided.

Findings similar to those described above can be observed during, before, and after distention of the renal pelvis for retrograde pyelography in patients suffering from one form or another of renal disease. In these cases, a careful study of the entire gastrointestinal tract shows: (1) that the stomach is dilated and the pylorus spastically closed for over three hours; (2) that some loops of the small intestine are dilated, with absence of the normal mucosal pattern, with marked visibility of the valvulae conniventes, and with diminished peristalsis and definite enlargement of the lumen, whereas other loops, on the contrary, are spastically contracted; (3) that the colon is greatly dilated and elongated, with absence of haustration and with inability to empty itself spontaneously. According to our records, all these disturbances are absent the day before the pyelography, and disappear in the course of two days after it. On the other hand, retrograde pyelography fails to elicit the disorder in those patients in whom there is already a marked distention of the

Fig. 3. Small intestine, region of jejunum. Roentgenogram taken twenty-five minutes after oral ingestion of 100 cc. of opaque meal, and three minutes after introduction of a catheter into the right renal pelvis. Marked dilatation of the intestinal loops. The opaque shadows remained almost immovable for the subsequent eight hours. Repetition of the examination after forty-eight hours showed a perfectly normal digestive tract. A case of pyelitis with colicky pain.

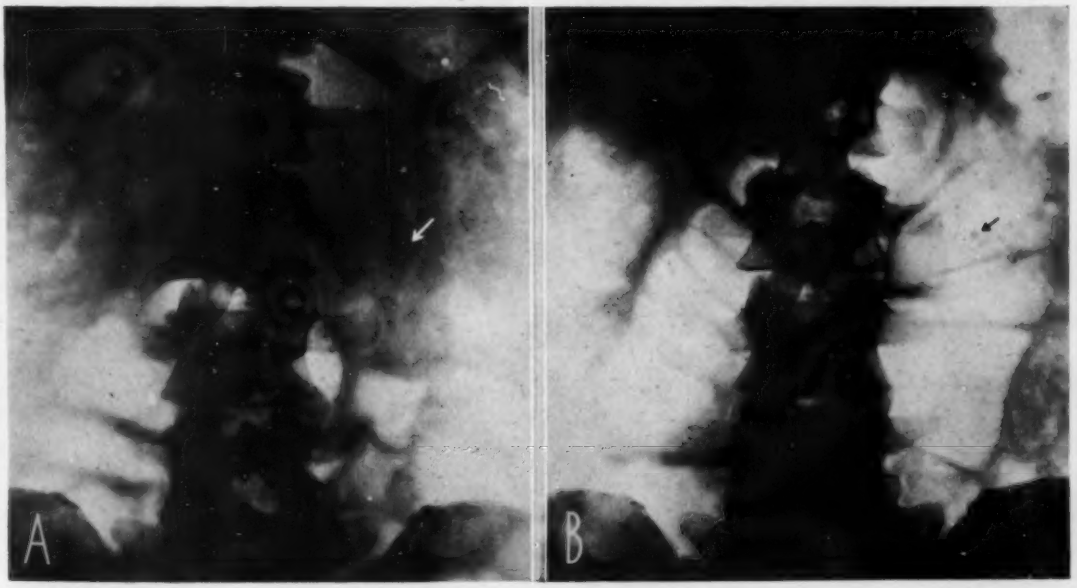

Fig. 4. Small calculus (arrow) in left renal pelvis. Roentgenogram during absence of pain *A*, and during renal colic *B*. Colonic distention in *B*.

renal pelvis owing to the presence of large calculi or to some other chronic affection. From these findings it is obvious that what leads to the development of the symptoms described is the irritation produced by the distention of a sensitive renal pelvis: even intravenous urography leads occasionally to moderate degrees of intestinal dilatation in patients who are in the acute stage of an affection of one part or another of the urinary tract.

The roentgenological aspect of the dilated intestines is characteristic of atony: there is increase in both length and width, disappearance of the mucosal "autoplastic" activity, and deficient peristalsis.

These observations explain also the appearance of that so-called gaseous distention which interferes so commonly with clear visualization of the kidneys on plain roentgenograms. That the gas is not due to some kind of abnormal intestinal fermentation (as is commonly assumed) is evident from the fact that it appears very suddenly, within a few minutes after introduction of the catheter. Furthermore, we have never been able to convince ourselves that any of the carminatives recommended for getting rid of the gas have any definite effect upon this kind of distention; in a number of crucial experiments we found that, *ceteris paribus*, and after a few days of rest, the gas disappears without treatment as often and as promptly as with it. The mechanism underlying gaseous distention is the acute atony of the intestinal tract, but the question remains as to where the gas comes from. It would seem that the sudden increase of gas in this form of acute atony is of the same nature as that observed in paralytic ileus; i.e., that some of the gas is swallowed, some derived from the blood by diffusion, while a large part accumulates of necessity in the distended loops as fast as it is expelled from other loops which are spastically contracted.

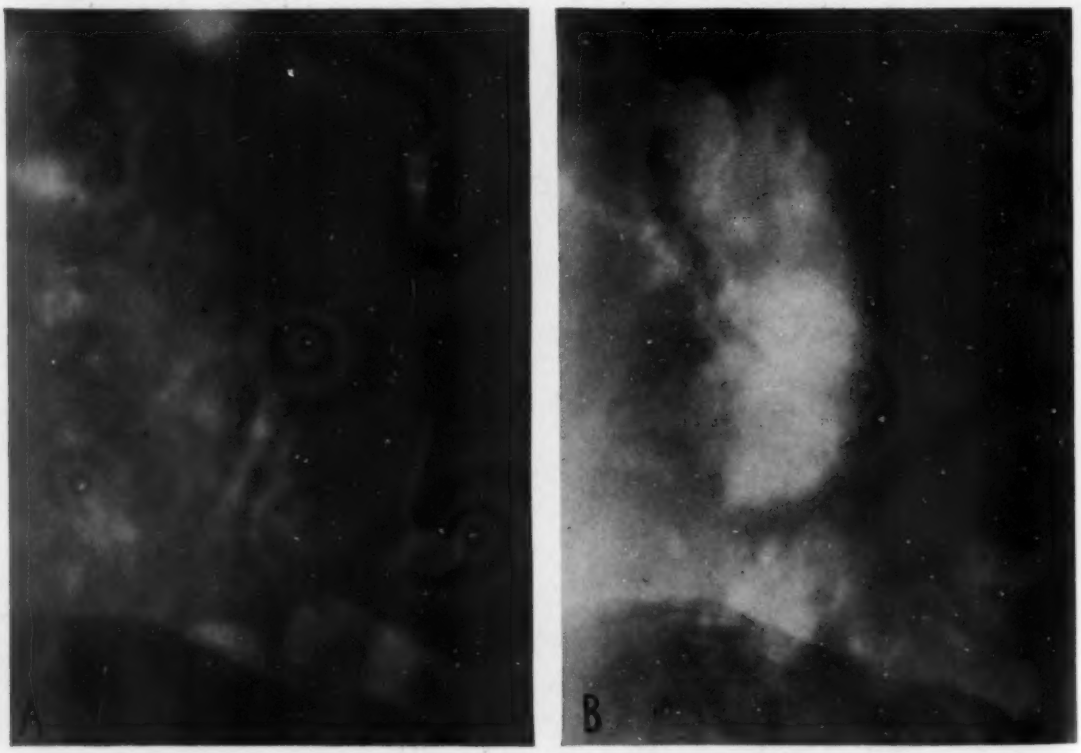

Fig. 5. Small intestines before, *A*, and during renal colic, *B*. Distended intestinal loop in *B*. Note the similarity in appearance between this loop and those shown in Figure 3.

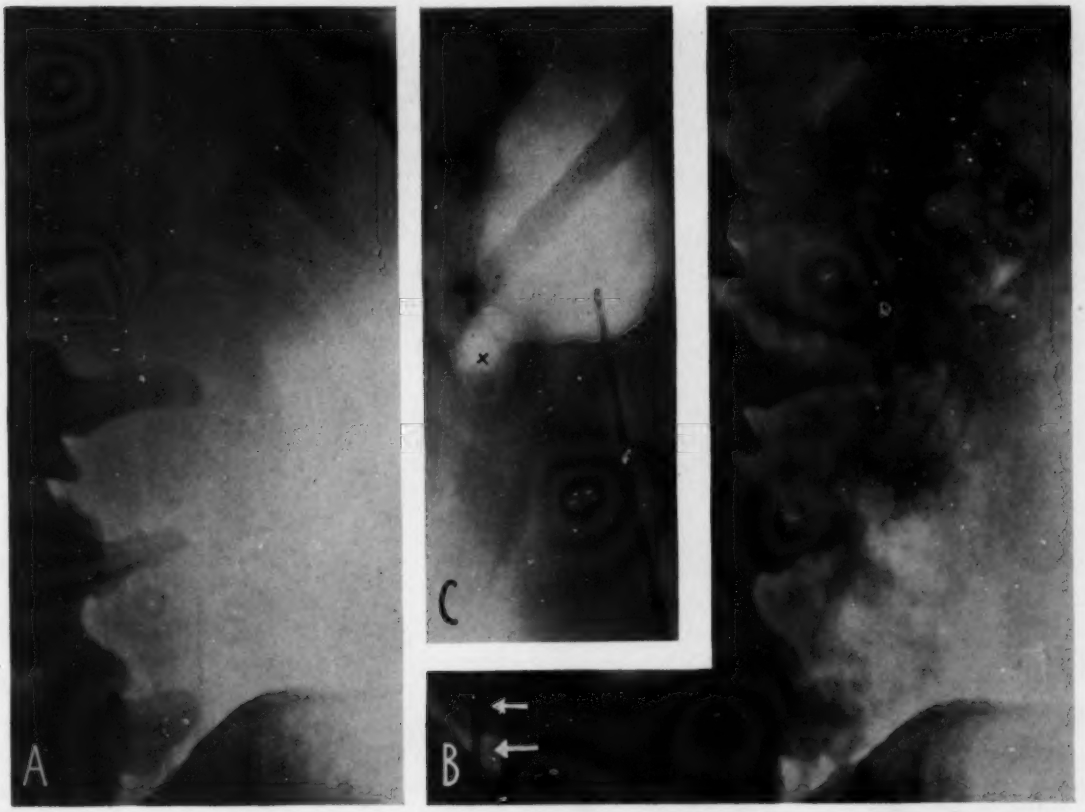

Fig. 6. Roentgenograms taken before, *A*, and three minutes after distention of the right renal pelvis with oxygen, *C*. The arrow in *B* points to the catheter. Distention of small intestines, visible valvulae conniventes. Renal calculus, ×.

McIver, Benedict and Cline also saw the stomach empty its gas into the small intestine after stimulation of the splanchnics; accordingly, in peritonitis of cats, they found no gaseous distention of the intestine when the pylorus was ligated. In man, this mechanism was not demonstrable either in the experiments above described or in observations on patients with pyloric obstruction; gas is here expelled by eructation rather than by passage into the gut.

CONCLUSIONS

Acute atony of the colon, the stomach, and parts of the small intestine, with spasm of the pylorus and of some intestinal loops, occurs as a result of either spontaneous or artificial irritation of the urinary tract, in disease of the gallbladder, and in other types of colic. The rapid disappearance of this atony proves that the intestinal muscle itself is not damaged. This confirms the results reported by Alvarez, who found that in experimental paralytic ileus the excised intestinal muscle responds normally to stimulation. Both Alvarez' experiments and our own observations lead to the conclusion that paralysis of the intestines, whether transient or persistent, may be produced by inhibitory impulses acting upon the digestive tract. Alvarez showed that this inhibition may be produced by irritation of the peritoneum, and our findings prove that it may originate also in extraperitoneal organs such as the renal pelvis. This observation explains also the fact that urinary disorders often induce gastrointestinal symptoms, even when there is no question of uremic poisoning;

for example, Cecil found that in 28 per cent of his patients digestive disturbances were the only symptoms of hydronephrosis and urinary calculi. From the practical point of view, it is important to know that megacolon, as well as gastric and intestinal disorders, can be simulated roentgenologically by the conditions here discussed. This goes once more to prove that, roentgenologically, functional disorders may resemble actual anatomical changes, especially as regards the digestive tract.

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ANNULAR SHADOWS IN THE TUBERCULOUS LUNG TREATED WITH PNEUMOTHORAX*

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ANNULAR shadows seen in the roentgenogram of the lungs was a subject of frequent debate in the past and the literature prior to 1927 bears witness to many a conclusion which we now know to be erroneous. Some authors were of the opinion that annular shadows were caused by ulceration and rupture of the tuberculous lung; the rupture, supposedly, gave rise to pneumothorax pockets which were localized because of adhesions and appeared as ring-like shadows on the roentgenogram. Others called these annular shadows "pleural" and ascribed them to subacute or chronic localized pleurisy. Definite knowledge of the nature of the ring-like shadow was not forthcoming until the last decade. More extensive use of the roentgen ray in diseases of the chest demonstrated that annular shadows may be seen in lungs that show no evidence of pulmonary tuberculosis. It was also noted that these shadows were frequently associated with pulmonary emphysema and affections in the chest that produce intrinsic or extrinsic obstruction in the smaller bronchi. Arnell[1] in 1927 reported a case of non-tuberculous pulmonary disease in which the roentgenogram showed annular shadows that proved, on post-mortem examination, to be emphysematous bullae. Laurell[5] proved experimentally that emphysematous blebs and bullae appear as annular shadows on the roentgenogram. He is of the opinion that these shadows can appear around atelectatic areas and they can become tuberculous cavities when infected with tubercle bacilli. Hayashi[3] reported 4 cases of bullous emphysema that were examined post mortem and the lungs were studied grossly and microscopically. The bullae were found in the region of tuberculous nodules and upon pressure on the surrounding lung tissue the bullae became enlarged, while it was somewhat difficult to express the trapped air when pressure was applied directly to the bulla. He found microscopically a barely perceptible opening into the bulla through which air could enter, the nearby alveolar spaces were markedly narrowed by a deposition of fibrous tissue causing elongation of the passage and a valve-like arrangement permitting air to enter on inspiration and shutting the passage off on expiration. Kjaergaard,[4] in a study of the cause of spontaneous pneumothorax in the apparently healthy, examined serial sections of the lungs microscopically and, similarly, found a valve-like mechanism in the bronchioles leading to emphysematous bullae. He was convinced that such a mechanism would not permit the escape of air from a bulla during expiration, and he also expressed the opinion that scar tissue can act as a valve mechanism. Freedman[2] reported 5 cases in which the roentgenograms showed annular shadows that were diagnosed to be emphysematous blebs and bullae. Autopsy findings on 4 of his patients confirmed the diagnosis. Only 1 of his cases had pulmonary tuberculosis, and a ring-like shadow in the roentgenogram that was interpreted as a tuberculous cavity proved at post mortem to be an emphysematous bleb. Miller[6] reported a case of pulmonary tuberculosis in which an emphysematous bleb was mistaken for a tuberculous cavity.

A fair search of the American and foreign literature failed to reveal any reports of cases of emphysematous bullae occurring in tuberculous patients treated with pneumothorax. Two such cases were found in the pneumothorax clinic at the Grasslands

* From the Service of Dr. John M. Nicklas, Tuberculosis Division, Grasslands Hospital, Valhalla, N. Y.

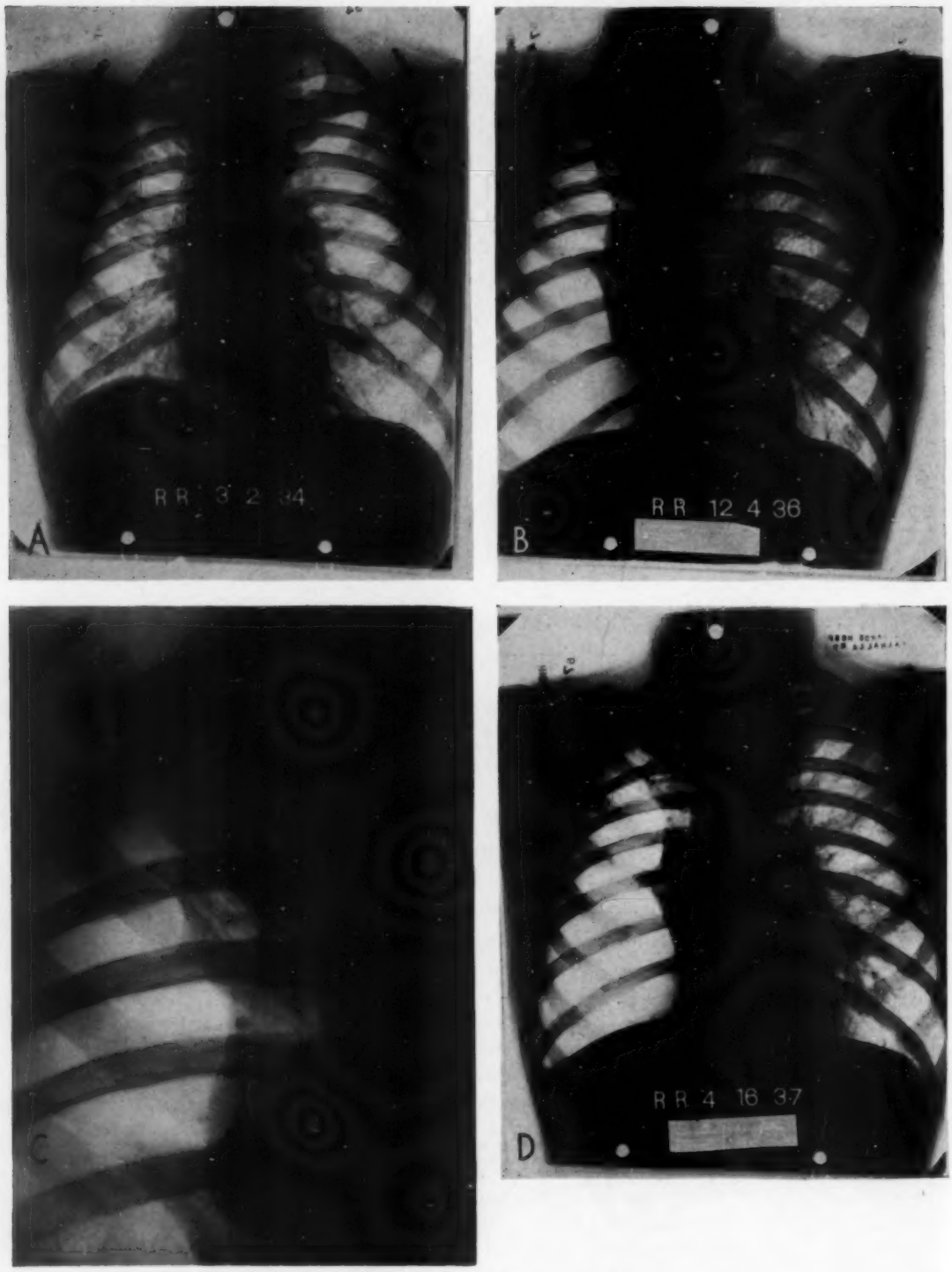

Fig. 1. Case 1. *A*, heavy nodular infiltration in upper third. *B*, pneumothorax, right. Two annular shadows: one faintly outlined in the right upper third and one definitely outlined in the midzone in the region of the right hilus. *C*, detail view of right upper third of *B*, showing slit-like passage towards the faintly outlined annular shadow, pinched off at its entrance. *D*, shows two definite annular shadows on the right side, one in the upper third and the other in the midzone in the region of the hilum.

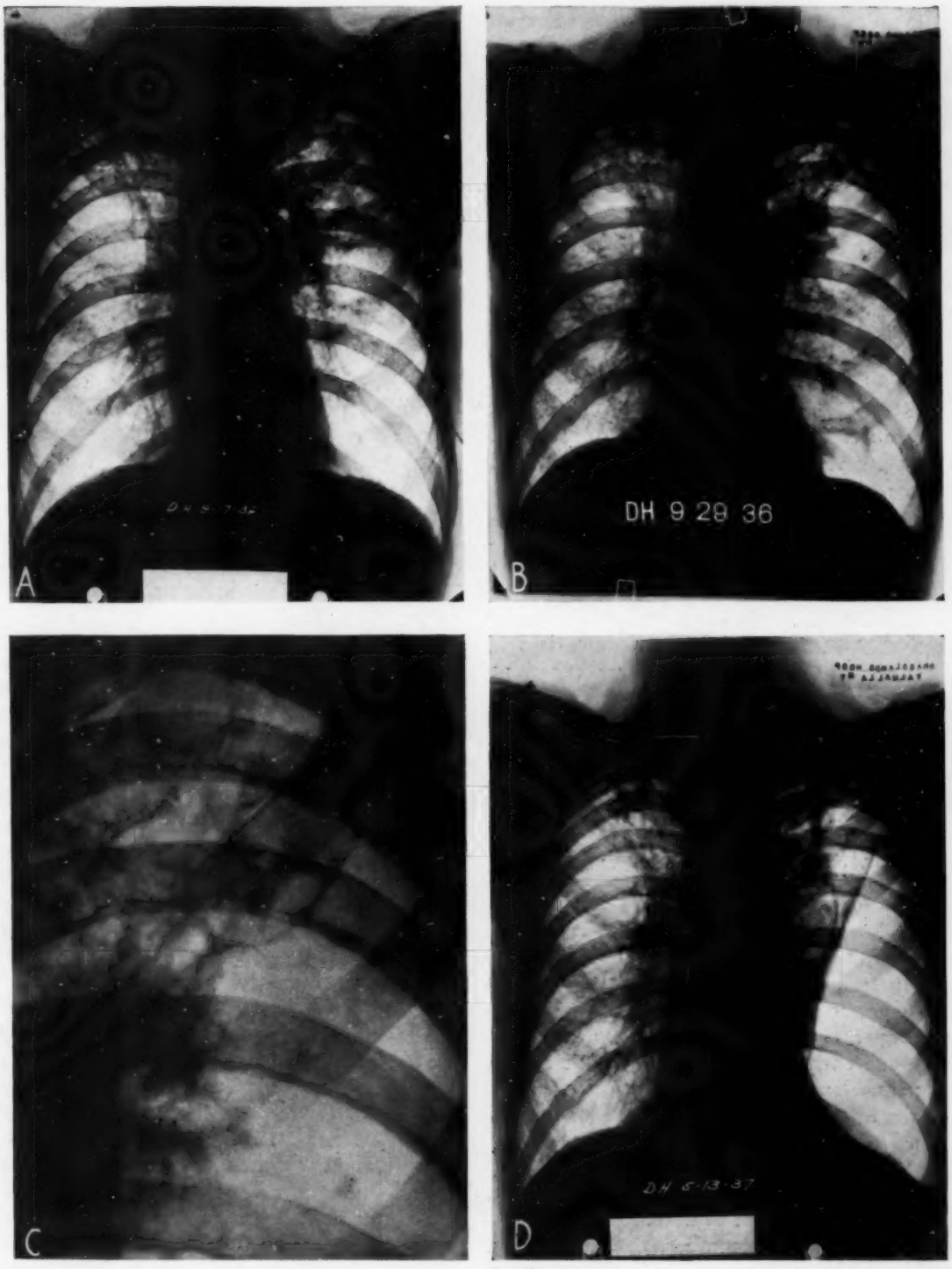

Fig. 2. Case 11. *A*, heavy nodular infiltration in the upper third of the right lung and similar infiltration in the upper half of the left lung with a 3 cm. cavity below the 7th rib posteriorly. Pulmonary emphysema. *B*, pneumothorax, left. Cavity still seen but decreased in size. An incompletely outlined annular shadow seen in the upper third under the 6th rib posteriorly. *C*, detail view of left upper third of *B*, showing narrow tubular passage that is pinched off at the junction with the annular shadow. *D*, two well outlined annular shadows on the left side, one in the upper third peripherally and the other in the midzone near the hilum.

Hospital and were considered worthy of the attention of the roentgenologist as well as of the phthisiologist.

Case I. R. R., a white man, aged thirty-nine, was admitted on December 6, 1933, complaining of cough and expectoration since August, 1932. A tonsillectomy was done in another hospital in December, 1932, to relieve his cough. Five days following the operation the patient had hemoptysis of 5 ounces. A roentgenogram was taken, tuberculosis was diagnosed and his physician advised rest at home. Because his cough persisted and a deviated septum was discovered in the nose, a consultant laryngologist advised a submucous resection and an antrum puncture. This was done in September, 1933, after which he still had his cough and expectoration. He was finally referred to the chest clinic, where hospitalization was advised. The physical examination revealed a well nourished man, not in discomfort. The right chest showed dullness, bronchovesicular breathing and coarse râles in the upper third. The lower two-thirds of the right lung and the entire left lung were clear. A roentgenogram taken at the time of admission showed an infiltrative process, productive in character, involving the upper third of the right lung with areas of honeycombing suggestive of small cavitation. The sputum was positive. There was no evidence of pulmonary emphysema. A diagnosis of pulmonary tuberculosis was made and absolute bed rest prescribed. Periodic roentgenograms failed to show improvement, his sputum was persistently positive, a definite cavity was seen in the right upper lobe (Fig. 1, *A*) and pneumothorax was instituted on the right side on July 20, 1934. The vital capacity was 4,100 cc. (92 per cent). A free pleural space was found, the extreme apex was adherent and a string adhesion was seen in the midzone arising from the lower lobe. His sputum became negative in December, 1934, and has been negative since that time. He was discharged in May, 1935, and his pneumothorax is continued in the out-patient department to date. A serial roentgenogram taken in December, 1936, showed a faintly outlined annular shadow in the adherent upper third of the right lung and a definitely outlined ring-like shadow in the midzone of the same lung (Fig. 1, *B*). Close inspection of the apical region shows a canal-like structure of greater illumination, not unlike a small bronchus, that becomes pinched off as it extends towards the periphery (Fig. 1, *C*). Subsequent roentgenograms showed a gradual increase in the annular shadows in the right upper third and in the midzone; a roentgenogram taken in April, 1937, showed two well developed emphysematous bullae, one in the upper third of the right lung and another in the midzone of the same lung (Fig. 1, *D*). To date the patient is in good condition, working every day, expectorates about 2 cc. daily. The intrapleural pressures were always negative.

Case II. H. D., a white man, aged fifty-two, was readmitted on September 15, 1936, complaining of cough and expectoration. The onset was in May, 1933, when pulmonary tuberculosis was diagnosed and he was admitted to the tuberculosis division of Grasslands Hospital in July, 1933. The physical examination revealed a well developed man, his chest was emphysematous, there was dullness in the upper third of each lung, distant breath sounds and many coarse râles. The lower two-thirds of each lung showed hyperresonance and distant breath sounds. The roentgenogram showed productive infiltration involving the upper third of each lung with bilateral cavitation. The remainder of the lungs showed emphysema. The sputum was persistently positive. His vital capacity was 3,400 cc. (63 per cent). After a lengthy period of bed rest the infiltrations cleared somewhat; his cavities, however, remained open and the sputum was about 2 ounces in amount and positive. He was discharged to a boarding home in May, 1935, as quiescent. A follow-up examination in August, 1936, showed a decrease in the size of the cavity on the right and an increase in cavitation on the left (Fig. 2, *A*). He was readmitted for pneumothorax therapy on the left side. Treatment was begun on the left on September 24, 1936, and a free pleural space was found. A roentgenogram taken five days later showed a partial pneumothorax on the left side, the cavity had become definitely smaller and a thin-walled annular shadow was noted in the upper third (Fig. 2, *B*). Close inspection of the region of the ring-like shadow shows an elongated structure that arises from the hilum. It is tubular in shape and narrows gradually to a point from which the annular shadow arises (Fig. 2, *C*). Subsequent roentgenograms showed gradual development of two annular shadows, and a roentgenogram taken in May, 1937

showed two thin-walled shadows, one in the upper third of the left lung and one in the midzone of the same lung (Fig. 2, *D*). The patient's sputum became negative in April, 1937, and has been negative on six consecutive monthly examinations by the concentration method. His expectoration decreased from 2 ounces on admission to 2 drams. The vital capacity is now 1,700 cc. (33 per cent). He was discharged in July, 1937, in good condition and is receiving refills in the out-patient department. The intrapleural pressures were always slightly positive with a maximum of +8 on expiration after refill.

COMMENT

Generalized pulmonary emphysema is apparently not a prerequisite to the formation of emphysematous bullae since Case 1 at no time showed any evidence of generalized pulmonary emphysema. The annular shadows seen in both cases are not tuberculous cavities since they appeared after pneumothorax was begun and there was no evidence of extensive caseation that could have undergone sequestration after collapse therapy was started. The annular shadows made their appearance without clinical symptomatology of progressive disease and the sputum is, and had been for many months, scanty. The fact that the bullae appeared some time after the pneumothorax was started suggests that the mechanism responsible is probably the same described by Hayashi[3] and Kjaergaard,[4] that is, when the collapse of the lung under treatment reached a certain stage, the valvular mechanism was created by the partial collapse of the bronchioles by the pneumothorax in addition to a preexisting narrowing caused by tuberculous nodules and fibrous tissue in those areas. Gradual increase in collapse by pneumothorax eventually caused enough constriction of the bronchioles to create partial or complete occlusion of the lumen during expiration, thus trapping the air that enters during inspiration behind it and causing bullous emphysema. Whether the constrictions seen in the roentgenograms (Figs. 1, *C* and 2, *C*) are responsible for the development of the bullae in the cases presented is a matter of speculation.

Apparently the presence of bullae in a collapsed lung does not preclude the possibility of an effective pneumothorax. The intrapleural pressures seemingly play no part in the formation of emphysematous bullae, since it was negative in Case 1 and slightly positive in Case 11. What would happen to a chest cavity and the patient should an emphysematous bulla rupture, can only be surmised, since I have witnessed no such accident. Assuming the ball valve mechanism a fact, a tension pneumothorax could be expected. On the same basis one should expect progressive increase in the bulla until the entire hemithorax is filled, This has not occurred so far, weekly roentgenoscopy and periodic roentgenograms having showed no marked change in the past six months. I cannot state with surety whether a certain equilibrium between the intrapleural pressure and the tension in the emphysematous bulla is reached which automatically shuts off the ball valve and reopens it when the intrapleural pressure drops, thus determining the size of the bulla. On roentgenoscopic examination during very deep inspiration the annular shadow increases in size noticeably. The latter fact also eliminates the possibility of these shadows being pneumothorax pockets or pleural rings.

CONCLUSIONS

1. Large annular shadows appearing in a roentgenogram of a tuberculous lung after collapse by pneumothorax in cases that show no evidence of progressive disease are probably emphysematous bullae, not tuberculous cavities.

2. The presence of emphysematous bullae in a collapsed lung does not interfere with the effectiveness of pneumothorax, when such treatment is otherwise possible.

3. A tuberculous lung in which bullae appear after collapse by pneumothorax requires no other treatment than a collapsed lung with similar tuberculous pathology and free of bullae.

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OSTEOMA OF THE SKULL

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ON MARCH 15, 1937, A. O., a male, Italian, aged forty-five, entered the Medical Clinic of the Jersey City Medical Center complaining of a weakness of the middle, ring and little fingers of his left hand, and middle and ring fingers of his right hand, as well as a feeling of weakness in his left wrist. The onset of this was in December, 1936, and developed to the extent where he was unable to pursue his trade as a painter.

In January, 1937, he went to a physician who gave him some medicine to take and prescribed massage, both of which were ineffective. He had no complaints referable to his lower extremities. In view of the patient's occupation as a painter for the past thirty years, he was referred to the Dental Service where he was seen by Dr. George Hamilton, who found no evidence of a lead line or any roentgen evidence of lead deposits in the bones of the jaw.

Because of a most unnatural projection of his forehead and a bilateral exophthalmos, he was referred to the Department of Roentgenology for further study. The subsequent findings were so unusual that the case is reported in detail.

As far back as the patient can remember, he has had a prominence of his entire forehead. A picture taken at the age of four shows this to be true at that time. Twenty-five years ago, he noticed that the projection on his forehead began to be more marked, and at the same time his eyes began to bulge. As the vision in his left eye had been very poor since the age of thirteen months, when he was operated on in Europe for a cataract, and the vision in his right eye has always been good, he noted no visual disturbances, even though the exophthalmos became more marked with time. It is of interest to note that the patient's two brothers, father and grandfather had similar forehead prominences, but none ever had an exophthalmos. This finding was proved from a photograph which the patient showed us of his family taken when he was four years old. One brother is still living, one died at the age of twenty-seven of a meningitis and his sister died in childhood, cause unknown. In Figure 1, the boy standing in front to the left is the patient (I). The boy on the right (II) is his brother who is living; the boy behind him is the brother who died of meningitis (III), and the infant is his sister (IV) who died of causes unknown.

It is striking to note that although both tables of the frontal bone were involved, he has never had a headache, nor any symptoms to suggest cerebral involvement. His mentality was normal and he was very cooperative. He has never had any sinus trouble nor symptoms referable to the cardiorespiratory system. Patient's appetite had always been fairly good and since a cholecystectomy done thirteen years ago, at which time several gallstones were removed, patient has never had any colicky abdominal pains and can now tolerate all foods. Venereal diseases were denied. Patient has been married for twenty-six years and has no children.

FIG. 1

Fig. 2

Physical Examination. This revealed a well-nourished and well-developed white male, aged forty-five, who did not appear acutely or chronically ill.

Head: Extending anteriorly from the level of the coronal suture is a bony, hard, nodular, immobile elevation involving the entire frontal bone (Figs. 2 and 3). Projecting into both orbits from the medial surfaces of the supra-orbital bone is felt a nodular bony projection.

Eyes: There is noted a forward and lateral displacement of both eyes, more marked on the right. The right pupil is fixed to light and accommodation, with the fundus appearing normal and vision normal. The left pupil showed evidence of an iridectomy with its fundus not visualized and vision greatly impaired. Patient was seen by Dr. Francis Brophy, attending physician on the Eye Service, who made the diagnosis of adherent leukoma and complicated cataract from perforating ulcer of infancy (ophthalmia neonatorum).

Nose: No septal perforation.

Teeth: Several missing; those present are carious. No lead line visualized.

Pharynx: Normal.

Trachea: In midline.

Thyroid: Not enlarged; no glandular adenopathy.

Heart: Apex in the fifth interspace within the midclavicular line. Sounds have a good quality and regular sinus rhythm. No murmurs or thrills. Blood pressure 120/76.

Lungs: Equal expansion of both sides with no atrophy of the thoracic tissues noted. Negative to ausculation and percussion.

Abdomen: There is a healed upper right rectus scar. No tenderness. No masses. Liver, spleen and kidneys not palpable.

Genitalia: Normal.

Laboratory Findings (Dr. Angelo Gnassi). Hemoglobin, 90 per cent; red blood cells, 3,500,000; white blood cells, 5,200, with 76 per cent polymorphonuclears and 24 per cent lymphocytes. The urinalysis and Wassermann reaction were negative. Sugar, 104 mg. per 100 cc.; non-protein nitrogen, 28.6 mg. per 100 cc.; serum calcium, 10.7 mg. per 100 cc.; serum phosphorus, 3.3 mg. per 100 cc.; serum phosphatase, 4.4 mg. per 100 cc.

Roentgen Findings. Examination of the skull, made in three planes as illustrated in Figures 4, 5 and 6, reveals the following: There is a dense rounded shadow involving the frontal area of the skull, beginning at about the level of the coronal suture and projecting forward, protruding beyond the normal limit. The posterior edge of this shadow is quite roughened and fairly irregular and merges with the normal bone. The remainder of the calvarium is of

Fig. 3

normal size and contour, with no structural changes evident. The sella turcica is of normal size and contour with no unusual approximation of the clinoid processes. There is no indication of intracranial pathology, beyond the solid shadow. In the lateral and posteroanterior views, there is also noted an unusual density involving the superior maxilla and zygomatic process. This obscures both maxillary antra, but the density would indicate that it is bone that is involved rather than infection of the antrum itself. The predominating feature of

Fig. 4

this case is the presence of two irregular dense shadows protruding downward from the orbital plate of the frontal bone. On the right side, this shadow measures approximately 3.25 by 2.5 cm. On the left side, it is about 2.25 by 2.0 cm. These bony projections which extend into the orbit cause the exophthalmos. The remaining bones of the superior and inferior maxillae show no structural changes. The findings are those of an osteoma. Examination of the entire spine showed extensive proliferative changes, indicating the presence of a hypertrophic osteo-arthritis. Examination of the pelvis and bones of the femurs, forelegs, feet and hands, failed to demonstrate the presence of any structural changes.

Neurological examination by Dr. Henry Cotton, of the Neurological Service was as follows: "There is weakness of the extensors of

Fig. 5

the left wrist with resultant wrist drop. There is also weakness of the extensors of the third, fourth and fifth fingers of the left hand. There is weakness of the right middle and ring fingers. No atrophy of the hand muscles was evident. Inasmuch as the patient gave a history of long

Fig. 6

exposure to lead as a painter it is felt that these palsies are the result of lead neuritis and in no way related to the head condition. The deep reflexes are equal and active. Abdominals equal and active. No Babinski, clonus or Hoffmann sign obtained. No disturbances of sensation found. Aside from the palsies mentioned above, there are no disturbances of motor function."

DISCUSSION

Local thickening of the skull may occur in a number of conditions; Paget's disease, acromegaly, periosteal inflammatory conditions, endotheliomas and actual tumor formation being a few of the more common ones encountered. Cushing found in a study of 80 endotheliomas that 20 showed hyperostosis of the skull. The process in this type of case is due to invasion of the bony canals by tumor cells with resultant stimulation of osteoblasts and the production of new bone. It is because of this hyperostosis that many of these meningeal tumors are recognized, for many give no intracranial symptoms. Those that arise from the temporofrontal meninges and those which are of the flat type seem to be accompanied by hyperostosis cranii the most often. Osteomata arise from the accessory nasal sinuses or take their origin from the periosteum or even from the cancellous portion of the bone itself. The so-called orbital osteomata are isolated and detachable tumors which, according to Cushing, inevitably originate on the ethmoidal side of the inner orbital wall. Osteomata of the accessory sinuses are, as a rule, composed of a central portion of cancellous bone with an outer layer of compact bone. They may, however, be made up entirely of compact bone with tortuous haversian canals, as noted in a case reported by Browder. It is of interest to note that many of these cases give a history of trauma at the site of the growth.

These tumors are essentially benign. They are slow-growing, though at times they may increase in size fairly rapidly. The seriousness of this type of tumor lies in the fact that by nature of its growth, it may encroach into the cranial cavity with subsequent pressure symptoms, or it may encroach upon the orbit with displacement of the eyeball.

SYMPTOMATOLOGY

There may be no symptoms in the early stages. The patient may or may not be aware of a localized painless growth which does not interfere with his wellbeing in the least. Should the osteoma be one of the frontal sinus, the only complaint may be one of acute frontal sinusitis and only a roentgen examination will reveal the growth. Should the growth invade the cranial cavity, severe headaches, mental derangement and even epilepsy may result. Encroachment into the orbital cavity will result in diplopia, proptosis and even a loss of vision due to pressure on the nerve. It is therefore not unusual for the ophthalmologist to be the first to see many of these cases.

DIAGNOSIS

In a number of these cases, a diagnosis can only be made from the roentgenogram, especially those which are confined to the frontal sinus. Examination may reveal a hard, immobile, painless mass of variable size which may or may not be associated with cerebral or ocular symptoms. Cranial osteomas must be differentiated from the meningeal hyperostoses. In the latter, the new bone formation shows on the roentgenogram more definitely radiating spicules which extend at right angles from both the inner and outer tables of the skull. In addition, they occur in adults, are accompanied by intracranial symptoms and grow rapidly. Osteomata, on the other hand, grow slowly, have their onset in childhood, and usually produce no intracranial manifestations, and the roentgenogram shows a dense mass of new bone with a smooth convex outer border. It is needless, of course, to add that every case of unilateral exophthalmos should have an anteroposterior and a lateral roentgenogram of the skull taken to rule out the possibility of an orbital osteoma.

TREATMENT

The treatment in these cases is surgical, with removal of the bony tumor with the underlying tumor, if one is present. Even though the patient is asymptomatic, this should be done, for sooner or later, because of the slow but gradual growth of the bone, it will encroach either upon the ocular structures or upon the cerebrum with resultant disturbance of function of the involved structures.

SUMMARY

1. We have presented a case which was of unusual interest to us because of the extensiveness of the bony involvement, and because of the bilateral bony pedunculated projections into both orbits causing marked displacement of both eyeballs, and although this has been gradually progressing for years and encroaching upon the cerebrum, the patient has remained cerebrally asymptomatic.

2. Because of its onset in childhood, the slow growth of the process, the absence of symptoms and the roentgenological picture, we believe this to be a benign osteoma of the skull with no underlying tumor.

3. The possibility of the condition being hereditary is suggested.

4. Because of the extensiveness of the process with involvement of both orbits and practically the entire frontal bone, and because of the wellbeing of the patient, we have not advised surgery in this case.

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PULMONARY HEMOSIDEROSIS*

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HEMOSIDEROSIS is the name given to a process in which a relatively insoluble iron pigment, hemosiderin, is laid down in the tissues of the body. It has not had a clear clinical and roentgenological background, but it has been of considerable interest to chemical pathologists who have found it in relatively small quantities in necropsy specimens. While repeated observations have established quite well the late stages of pathogenesis, attempts to produce hemosiderin experimentally have not met with real success. Principally the liver and spleen, less often the lungs, have contained this pigment. The case of interest in this report not only contained innumerable widely scattered deposits of this substance in the lungs, but many deposits were large enough to register as minute densities upon roentgenograms. In a previous communication,[1] attention was called to small interstitial agonal hemorrhages and slightly larger widely scattered hemorrhages into clusters of alveoli, which produced patterns on films made following death sometimes resembling the shadows produced by miliary tuberculosis and certain kinds of bronchopneumonia. The findings in this case reveal that minute repeated hemorrhages into the tissues over a long period, under certain circumstances produce deposits of a substance, hemosiderin, which contains a greater concentration of iron than ordinarily found in blood, and account for fairly discrete shadows of varying size on chest roentgenograms not unlike that frequently noted following the inhalation of certain dusts.

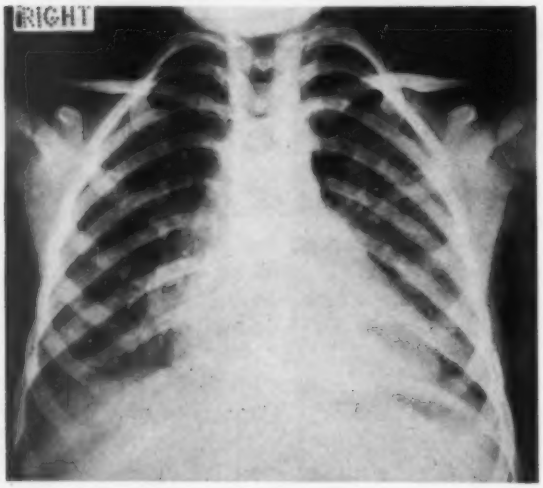

Fig. 1. C. M., aged seven; December 28, 1933. Note the numerous small semidiscrete shadows of varying size about the hila, which later are to become more discrete and extend out farther into the lung fields.

CASE REPORT

C. M., an Italian girl, aged seven, came to the Children's Memorial Hospital in November, 1933, with a history of having spent one year in the Cook County Hospital with a diagnosis of celiac disease and possible pulmonary tuberculosis. She had improved slightly and was sent home but had been there only a month when she again began to lose ground. Pallor, spitting of blood, and head sweating were the chief symptoms on her second admission to the hospital. The temperature varied from 99° to 100° from day to day. On physical examination the abdomen was large and soft and the liver and spleen were palpable below the costal margins. An apical systolic murmur was heard. The tuberculin test was markedly positive. It was thought that the patient had tuberculosis and secondary anemia (2,000,000 red cells). Roentgenograms of the chest showed diffuse clouding about both hila (Fig. 1).

Iron and ammonium tartrate was administered and the patient kept on a high protein diet for a few weeks. The hemoglobin rose from 20–30 per cent to 70 per cent. The liver receded so that it could barely be palpated. The

* This report is an outgrowth of Dr. Joseph Brennemann's plan, started in 1927, to check the cause of shadows on chest roentgenograms at necropsy.

sputum continued to be streaked with blood but no acid-fast organisms were found at any time. The condition of the patient continued unchanged for three months, then seemed to improve. The hemoglobin reached 78 per cent. The patient gained in weight, was playful, and seemed happy. On one occasion there was acute abdominal pain and the patient vomited and had a diarrhea for a day. Patient was later put on a meat-free diet. Stools were semiliquid and one to three per day, and occasionally contained small quantities of blood. No tubercle bacilli were found in the stool or sputum, although they were constantly searched for. The abdomen seemed to become more and more protuberant and it was thought that free fluid was present in the peritoneal cavity. The temperature continued to be slightly elevated. Roentgenograms of the chest after four months' hospitalization showed little change from that noted earlier except for the appearance of many fine, fairly discrete densities in the clouded zones.

For a period of several months the patient was relatively symptom-free, except for an occasional diarrhea, which lasted only a day or two. The hemoglobin remained around 80 per cent. The patient went home, but returned to the hospital five months later (August, 1934) because of a return of the original symptoms, i.e., spitting of blood, dyspnea, and loss of weight, enlargement of the liver, and severe anemia. The lungs at this time were negative

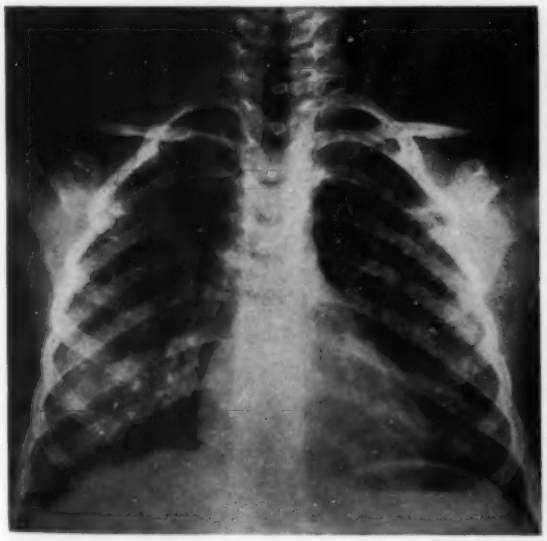

Fig. 2. Same case, four months later than Figure 1: May 1, 1934.

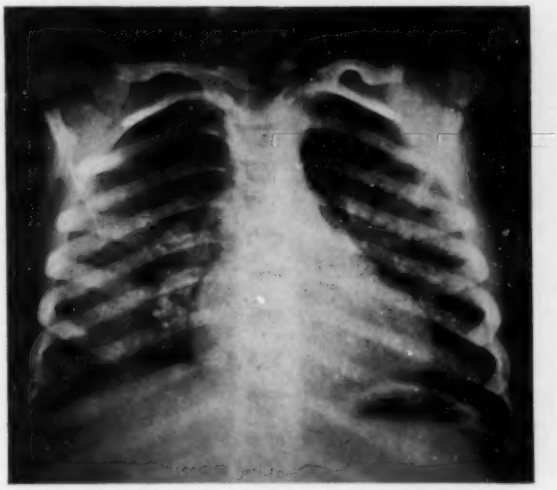

Fig. 3. Same case, fourteen months after Figure 2: July 2, 1935. Note the marked increase in the number of fine densities.

on physical examination. The symptoms gradually improved during the next four months. The signs of peritoneal fluid, thought to be present earlier, did not return. The benzidine test was repeatedly positive for blood. The presence of a tuberculous peritonitis or enteritis was strongly considered. The patient remained practically afebrile for six months. At no time were tubercle bacilli found.

The patient was in all admitted to the hospital three times, showing fairly rapid and steady improvement each time, until the time of the last admission, when she became more and more anemic. The physical findings were thought to be changed but little from those noted at the time of the first admission, twenty-three months previously. Most of the time she did not act sick, but there were periods of extreme pallor; often no abnormal sounds were heard in the chest. Paroxysms of coughing were finally followed by vomiting of a blood-stained froth. A transfusion of 250 cc. of blood failed to help and the patient expired on September 25, 1935, nearly three years after the first complaint.

Serial roentgenograms of the chest had shown little change from that noted at admission, except for increase in the number of fine densities in the clouded areas of both lung fields, somewhat resembling the roentgen appearance of silicosis. Mantoux tests with 1:10,000 dilutions were repeatedly positive, but tubercle bacilli were never found in the sputum, stools, or by lavage of the stomach. Wassermann tests of the

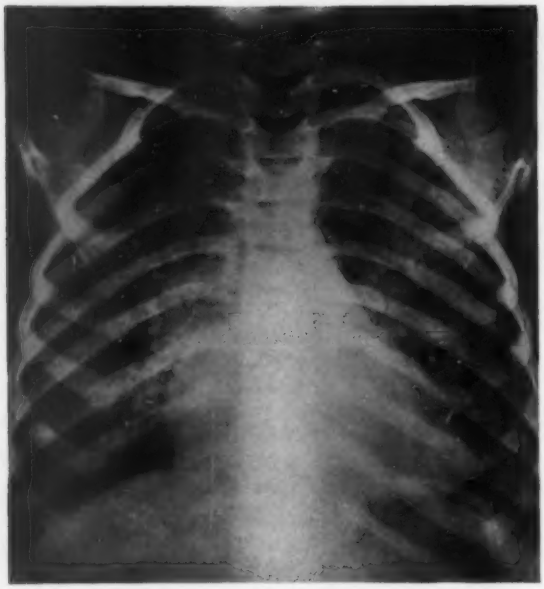

Fig. 4. Same case, three months later: September 9, 1935. The same quality of density present previously lateral to the hila, now partially obliterates the bases. The patient succumbed two weeks later.

parents were positive, but negative on the patient.

At necropsy, the heart showed no abnormal changes. The lungs showed extensive pneumonic consolidation, a terminal condition. Two small nodulations were found on the anterior surface of the right lung, one on the middle lobe and one on the lower lobe. These contained calcifications, as seen in a healed tuberculosis. A small pea-sized lymph node on the right was calcified. None of the nodes were caseous. The surface of the lungs was covered with an unusual speckled pattern of black dots which measured 2–3 mm. in diameter. The spleen, liver, and other abdominal organs failed to show any spectacular change. A histological study revealed widespread deposits of hemosiderin in the pulmonary tissue, also diffuse pulmonary hemorrhage, diffuse fibrosis, and a necrotizing arteritis.

COMMENT

The unusual clinical course and necropsy findings of this case leave much to be desired in explaining the condition. It was not entirely a surprise to find an unusual substance at necropsy because of the peculiar roentgen characteristics over a two-year period. The deposits of iron pigment (hemosiderin) were widely scattered throughout both lungs. It seems that, in all probability, this was the result of a necrotizing arteritis, which in turn was caused by an unusual combination of factors and not by any single process. The general distribution, the large number of the deposits, and the striking roentgen characteristics were the rare points attracting attention.

Why hemorrhages in the tissue should sometimes persist and show as areas of increased density upon pulmonary roentgenograms resembling small areas of calcification, or silica, becomes less of an enigma when one understands that the shadow is accentuated by the presence of an iron pigment, hemosiderin, which is highly radiopaque. The changes in the blood leading up to the deposit of this highly insoluble iron in the tissue is nicely set forth in Wells' description[2] of the change in extravasated blood which takes place soon after its escape.

In most situations sufficient fibrin ferment is formed to cause prompt clotting. If the blood does not become infected, the rapidity of subsequent changes depends chiefly upon the location and amount of blood. Small extravasations of blood into the tissues are subjected to the action of the tissue cells and of leucocytes emigrating freely from the capillaries; large masses

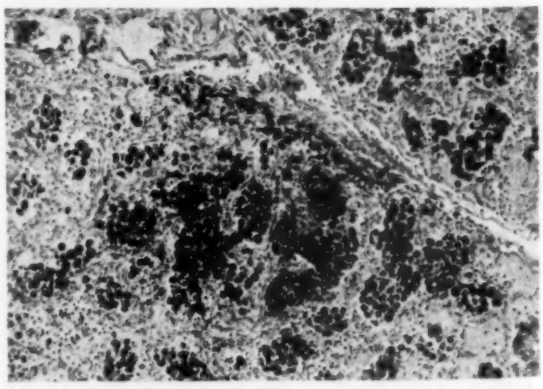

Fig. 5. Photomicrograph (potassium ferrocyanide × 125). Dark areas represent hemosiderin within the leukocytes. Numerous clusters of these accounted for the fine densities seen on the roentgenogram of the chest made during life.

of blood are but little affected by these agencies, the leucocytes within the mass soon die, and secondary changes go on very slowly. . . . The first products of the splitting of hemoglobin are: (1) The protein, globin, which constitutes 94 per cent of the hemoglobin, and (2) the iron-containing coloring matter, hematin (in the absence of oxygen the pigment is reduced hematin or hemochromogen). As hematin may be experimentally obtained by the action of proteoses upon hemoglobin, the decomposition of the hemoglobin in the tissues is probably accomplished in a similar way by the proteases of the leucocytes, tissue-cells, and blood plasma; the globin is thus digested away and the soluble products carried off while the insoluble hematin remains. The hematin gradually undergoes further changes, forming an iron-free pigment (hematoidin) and an iron-containing pigment (hemosiderin).

While hematoidin, in all probability, in bulk accounted in part for the early "soft" small densities, on chest roentgenograms at necropsy the iron-containing hemosiderin seemed to be present in almost pure form. The ultimate distribution of hemosiderin is further explained by Wells.

Hematoidin is nearly or quite identical with the bile pigment, bilirubin, and is absorbed from the hemorrhagic extravasation and eliminated as bilirubin in the bile. Possibly some of the hematoidin undergoes transformation into urobilin, and is then eliminated in the urine. Hemosiderin seems to be relatively insoluble and, therefore, is more slowly removed, so that it may be found at the site of a hemorrhage after the other evidences of blood extravasation have been removed. It may be easily demonstrated by staining with potassium ferrocyanide, the Prussian blue that is formed being readily distinguished. Unstained hemosiderin generally appears in the form of brown or yellowish-brown granules, never as crystals. After a time the hemosiderin is taken away, and probably is, to a greater or less extent, deposited in the liver and spleen, either as hemosiderin or as some other iron compound. Eventually it is probably utilized to make new hemoglobin; at any rate, the iron liberated by the breaking up of hematin within the body does not appear to be eliminated.

Schurig found that hemoglobin injected into the tissues is partly decomposed in situ with formation of iron compounds, but the greater part enters the circulation as hemoglobin and is partly converted into bile-pigment by the liver cells, the rest being converted into simpler iron compounds by the spleen, bone-marrow, and renal cortex.

While all but the hemosiderin is fairly readily absorbed, if the hemorrhagic extravasation has been large in amount, the deeper portions of the mass are not soon, if ever, invaded by leucocytes of tissue cells. Consequently, the blood is acted upon very slowly by the enzymes liberated by the leucocytes it contains itself and by the small amount of proteases in the serum. Furthermore, the products of decomposition are not soon absorbed, but accumulate in considerable amounts, so that often there is found crystalline deposits of hematoidin, sometimes even of hematin, hemoglobin, or parahemoglobin (Nencki) or methemoglobin.

This is in contrast to the predominance of an end product, hemosiderin in *small* hemorrhages, as was present in this case.

The similarity of the roentgen appearance to silicosis was noted fairly early in the course of the disease and caused a special investigation of the child's living conditions. The family lived above a bakery where the father was employed. This caused early speculation as to a possible etiologic factor such as the inhalation of flour from frequent visits of the patient to the bakery. Also because the residence was immediately above the bakery, the inhalation of smoke was considered for a time. Later it seemed evident that neither of these played any part in the pathogenesis. No other member of the family had pulmonary trouble although exposed to the same living conditions. At necropsy chemical tests for flour were negative. The abundance of hemosiderin found at necropsy in this case is so rare that most likely this condition should not prove to be a serious complication in the diagnosis of "industrial dust." That hemosiderin may be a roentgenological problem is the essence of this report.

SUMMARY

A case is described in which deposits of a relatively insoluble iron pigment, hemo-

siderin, accounted for minute densities on chest roentgenograms. These were seen to increase in number and size over a two-year period somewhat simulating changes following the inhalation of certain dusts. These findings and the unusual clinical course and serial roentgen findings caused considerable speculation as to the exact diagnosis.

Drs. Hibbs and Borowsky were responsible for the extensive work-up of necropsy material, which explained the shadows on the roentgenograms. Dr. Wells was responsible for the extensive histological investigation.

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THE LIMITATIONS OF KYMOGRAPHY IN THE DIAGNOSIS OF MEDIASTINAL TUMORS

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OF THE various refinements of roentgen technique which have been developed, we have regarded kymography as one promising to be most useful in the differential diagnosis of obscure mediastinal conditions. Its importance in cardiology is, of course, well established.

For the past year in the Division of Thoracic Surgery at Kings County Hospital, we have requested kymograms as a supplement to the routine roentgenologic studies before all operations in the mediastinum, and in several doubtful cases have found them very helpful. The advisability of operating on tumors of the mediastinum may, in certain cases, depend on knowing whether or not the tumor is pulsating. One cannot, of course, be certain of mediastinal pulsation without roentgenological studies. It is remotely possible that the local pulsation observed clinically may be due to local aneurysms of the subclavian or carotid. And although it has never been our inclination to place undue reliance on any laboratory finding, when three roentgenologists render independent reports of a non-pulsating non-vascular neoplasm in a case which we have diagnosed clinically as aortic aneurysm, we are inclined to revise our opinion, on the theory that so delicate an instrument would certainly pick up any pulsations present. These laboratory men believe that they can detect anything that is vascular in character. In the case herewith reported, however, this did not prove true.

Under ordinary circumstances we would not operate on an aortic aneurysm in a syphilitic patient, the disease having progressed as far as it had in this case. But in view of the insistence of the roentgenologists that the mass was non-pulsating, we felt that if there was any chance of its being a benign tumor, the patient should be given the benefit of the doubt. Furthermore in 5 recent cases of mediastinal masses pressing on the bronchus, we have found that a thoracotomy, making a window which relieved the pressure on the bronchus making it possible for the aneurysm to expand outwardly instead of pressing on the main bronchus and killing the patient, was well worth undertaking. With these two favorable possibilities in mind, we decided to operate.

CASE REPORT

I. J., male, colored, aged thirty-four, was admitted to the Medical Service of Kings County Hospital November 21, 1936. His chief complaint was cough of six months' duration. He had had almost constant sore throat since June, and dyspnea on exertion for several months; also occasional pain in the right shoulder. For the past month he had vomited almost daily. There was no edema of the ankles, and no pain in the chest.

His father had died of heart trouble, and his mother "lost her mind." His past history included the usual childhood diseases; pneumonia in 1923; gonorrhea in 1924; chancre in 1928 with no treatment until two months before consulting us. He had been shot in the eye in 1916, and had an exploratory operation following a stab wound "several years ago."

Clinical Findings. The patient was a well-developed, well-nourished colored male with a pronounced brassy cough and slight hoarseness, but not acutely ill. His temperature was 101° F., pulse 92, respiration 28. The left eye was enophthalmic, sclerotic, and functionless. The trachea was deviated to the right with a slight tracheal tug. There was palpable pulsation in the suprasternal notch; slight bulging of the chest with pulsations over the upper sternum, a little to the right of the aortic area; also dullness over this area. Moist râles in the base of the right lung posteriorly, with bronchovesicular breath sounds over both lower lobes posteriorly. Coarse râles over the left chest anteriorly. The heart was enlarged at the base,

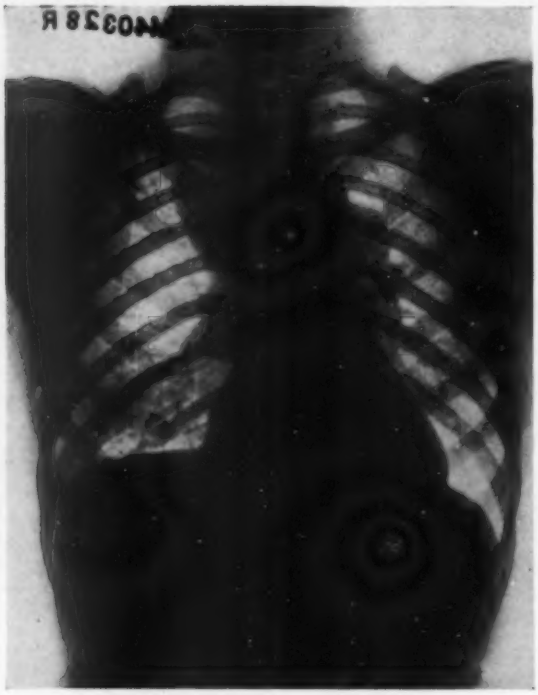

Fig. 1. Roentgenogram of chest showing mediastinal enlargement.

and a systolic blow was heard over the pulsating area. Soft blowing murmur was heard at the apex which was not transmitted. Blood pressure, right arm 122/96; left arm 110/84. The remainder of the examination was essentially negative.

Diagnosis on Admission. Luetic heart disease and aortic aneurysm.

Laboratory Findings. Urinalysis negative; blood count, hemoglobin, 85 per cent; red blood cells, 4,200,000; white blood cells, 9,500; polymorphonuclears, 76 per cent; lymphocytes, 24 per cent; Wassermann reaction, 4 plus. Bronchoscopy showed definite anteroposterior narrowing from the middle of the trachea down to its bifurcation.

Roentgen Diagnosis. Mediastinal tumor.

Roentgen Report, November 27, 1936. "The chest shows a large supra-aortic mass, about 4 inches in diameter. The heart is slightly enlarged. The aortic arch is deviated to the left by this mass, and there are moderate congestive changes at the right base (see Fig. 1). Kymographic examination showed this mass to be immobile, not pulsating, with cardiac or aortic movement. These findings are suggestive of mediastinal tumor rather than an aneurysm."

The chest roentgenogram was repeated on December 4, 1936, and another interpretation given, as follows: "Evidence of a mass adjoining the anterior border of the right ascending aorta and partially displacing it. This mass presents no pulsation. Findings are rather compatible with a new growth of the anterior and upper mediastinum on the right side."

The patient did not improve during this first stay in the hospital. With the hope of shrinking the mediastinal neoplasm and diminishing the patient's cough and the tracheal narrowing, 250 roentgens was given on December 17 and again on December 18. Following this there was slight improvement, the cough was not so bothersome and the patient was discharged to the Outpatient Division on December 18, 1936.

On January 2, 1937, the patient was readmitted to the Thoracic Service. He had gained weight since discharge and had received roentgen treatment. However, his hoarseness, cough, and dyspnea were worse. He remained under observation for thirteen days, when he refused to stay in the hospital longer and signed his release. He received two injections of bismuth salicylate in oil; one dose of 0.3 gm. neoarsphenamin and SS K.I. t.i.d.

Kymographic and roentgen studies made at

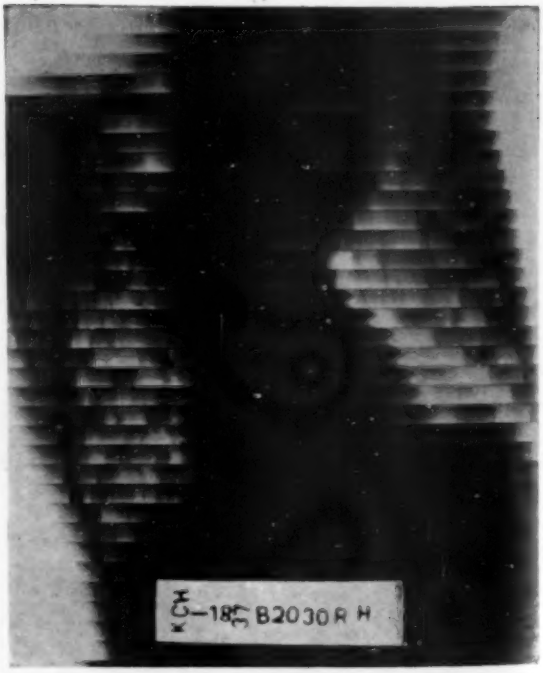

Fig. 2. Kymogram showing the most satisfactor view. No motion is shown.

this time (Fig. 2) still showed a non-pulsating supra-aortic mass, compressing the cervical trachea and with possible erosion of the sternum. The Wassermann reaction was still 4 plus. The blood count and urinalysis were essentially negative.

On May 6, 1937, the patient was readmitted to the Medical Division. His cough and hoarseness had become worse, and he experienced marked difficulty in breathing. Slight pain over the tumor mass radiated to the right shoulder, back and right side of the neck. There was a definite, though slight, raised area just below the inner half of the right clavicle. Pulsation could be palpated over this and was found to be synchronous with the heart beat. The lung fields were full of coarse râles on inspiration and expiration, with a prolonged expiratory phase. There was no change in the cardiac status. The blood pressure in the right arm was 124/88 and in the left, 120/90. On May 17, 1937, the patient expectorated some blood-tinged sputum. Bronchoscopy was done on May 19, 1937 and the report was "a resistant mass compressing the anterior tracheal wall in its lower portion. This reduced the tracheal lumen to a narrow slit which was more pronounced on the right side. The impression was that the pathology was not aneurysm; no pulsation noted." On May 22, 1937, roentgen examination and kymographic studies again showed "a non-vascular supra-aortic mass which appeared to be the result of either a mediastinal benign cyst or growth. It was further discovered that the soft tissues about the pelvis, axillae, extremities, and buttocks revealed multiple elliptical and regular areas of calcification. These findings appeared to be the results of calcified parasitic cysts. On further questioning, the patient claimed that when he was nine years old and living in South Carolina, he had passed long, round worms about 4 to 6 inches long in his feces. Neither ova nor parasites were found in the feces or sputa on numerous examinations. Eosinophiles ranged from 3 to 6 per cent. It was also noted that there was clubbing of the fingers, characteristic of chronic pulmonary suppuration. Two attempts to excise the cysts under local novocain anesthesia were unsuccessful. The cough and dyspnea were growing progressively worse. On June 11, 1937, it was finally decided to do a mediastinal exploratory operation to definitely rule out any possibilities of a non-vascular, mediastinal mass.

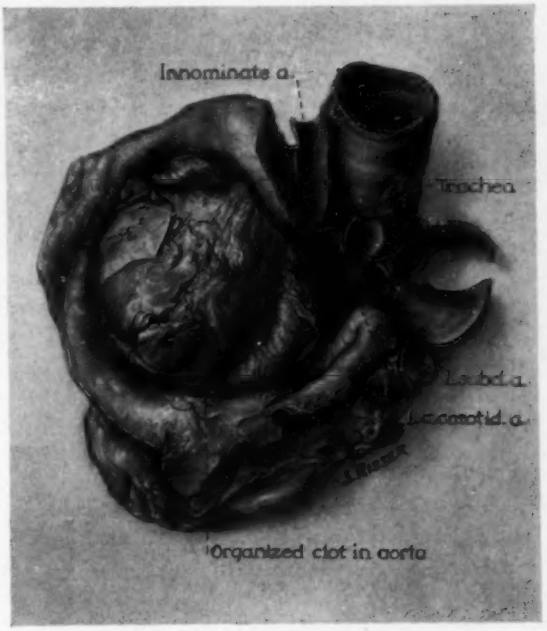

Fig. 3. Autopsy specimen of mediastinal mass, showing organized clot in the aneurysmal sac.

Operation. The pleura was opened horizontally; the left lung was found adherent. The lung parenchyma was also adherent and closely attached to the mediastinal mass. The surface of the mass was smooth, but slightly pulsating, and apparently vascular in character. The mass was very adherent to the posterior surface of the sternum. Further exploration failed to reveal any other pathology.

The diagnosis was aneurysm of the ascending aorta with very definite, but slight pulsation.

For several days the patient seemed better and claimed to be relieved. However, about seven days after operation, he began to have difficulty in swallowing anything but liquid foods; his difficulty in breathing became progressively worse. We felt that bronchoscopy might relieve the patient as it had before; so this was done on June 23, 1937, but without appreciable benefit. On July 2, 1937, the patient developed pulmonary edema and died.

Postoperative roentgen and kymographic studies on June 23 and June 25, 1937, revealed a supra-aortic mass with no evidence of any pulsation, and this finding would tend to exclude a vascular mass. There was no evidence of any pulmonary infiltration or consolidation.

Autopsy report on the mediastinal mass: Right lung is involved in a mass which lies between the sternoclavicular junction. This mass

was carefully removed, leaving a cup-shaped depression in the posterior surface of the sternum. *The mass is found to be the arch of the aorta, and consists of a saccular aneurysm filled with an old clot, concentrically arranged* (see Fig. 3). The clot measures 2½ inches in diameter and 1½ inches in thickness. Right lung is impinged upon by this mass so that the upper lobe is soft and soggy.

Cause of Death. Left lobar pneumonia. Saccular aneurysm of arch of aorta.

SUMMARY

A case is reported to show that although kymography is undoubtedly helpful in some mediastinal conditions, it may be misleading and should not be allowed to influence clinical judgment too greatly.

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DIFFUSE CALCIFIC DEPOSIT OUTLINING THE KIDNEY LOBULES ASSOCIATED WITH PARATHYROID ADENOMA

By H. R. BRINDLE, M.D., *and* W. G. HERRMAN, M.D., F.A.C.R.
ASBURY PARK, NEW JERSEY

MANY cases have been reported in which adenoma of the parathyroid is associated with kidney stone. The relation of this same adenoma to osteitis fibrosa cystica is well known, as is also the combination of all these conditions.

The case here reported is being presented not to add to this already long list, but rather because of the unusual distribution of the calcium, deposited in such a manner in the parenchyma of the kidneys as to outline the kidney lobules without the formation of free stones in the pelvis of the kidney. This case is also of interest because of the widespread skeletal involvement and the size of the parathyroid adenoma found.

Mrs. S. D., aged forty-seven, Polish, was admitted to Monmouth Memorial Hospital with pathological fractures of the right femur and left tibia and no previous history of fractures. She complained of weakness during the past few years, loss of appetite, polydipsia, polyuria and noctura. The symptoms increased in the summer and she felt better and stronger during the winter. She had lost 10 pounds in the last five months. Just prior to admission the patient fell and with relatively mild trauma fractured both legs.

Roentgenographic Examination. Roentgenograms of the right femur and left tibia and fibula revealed transverse fracture at the junction of the middle and lower thirds of the left tibia. The fracture line was through a cystic area of decalcification which had not broken through the cortex (Fig. 1). The fracture in the fibula was in the middle third and through a similar area of cystic degeneration. Throughout the tibia, fibula, and femur there were multiple areas of cystic degeneration eroding the cortex from the medullary side, but not expanding nor completely eroding it at any site. The bones roentgenographed showed a generalized decalcification. Additional roentgenograms were taken of the radius and ulna (Fig. 2) and of other long bones, of the dorsal and lumbar spine, the kidney region, the pelvis, and laterally of the skull. The multiple cystic areas and generalized decalcification previously noted were found to exist throughout the skeleton.

In the parenchyma of both kidneys there was a diffuse fine granular deposit of calcium roughly outlining the kidney lobules (Fig. 3), but apparently no stones were present in the kidney pelvis, ureters, or bladder.

FIG. 1

Laboratory Findings. Urine was negative except for trace of albumin; 35 to 40 pus cells per field.

The blood examination showed hemoglobin, 84 per cent; red blood cells, 4,200,000; white blood cells, 16,800; polymorphonuclears, 86 per cent with 14 per cent young cells; lymphocytes, 12 per cent; monocytes, 2 per cent; urea nitrogen, 50 mg.; sugar, 100 mg.; chlorides, 540 mg.; cholesterol, 140 mg.; total protein, 5.6 grams; Bence-Jones protein not present;

Fig. 2

phosphorus, 2.36 mg.; calcium, 15 mg.; Wassermann and Kahn reactions, negative.

Diagnosis. On the basis of clinical, roentgenographic, and laboratory findings, parathyroid adenoma was suspected and a diagnosis was made of generalized osteitis fibrosa cystica with bilateral diffuse deposit of calcium in the kidney parenchyma, probably due to parathyroid adenoma.

Operative Procedure. Patient was operated on and from the inferior posterior surface of the right lobe of the thyroid a parathyroid adenoma was removed weighing 7.8 grams.

The postoperative course was stormy and complicated by gradual renal failure. On the seventh day postoperatively the patient developed a gradually increasing fever and on the thirteenth day postoperatively the patient died.

Summary of Post-Mortem Findings. Postoperative abscess of the neck, adhesive pericarditis, adhesive pleurisy, calcification of mediastinal and hilar glands, chronic adhesive hepatitis, perisplenitis, ununited pathological fracture of the right femur and left tibia, decalcification and generalized osteitis fibrosa cystica of the bony skeleton. On cutting the cortex of the kidneys grittiness was felt against the knife blade. The gross examination revealed myriads of fine sand-like grains scattered through the parenchyma, but none in the pelvis of the kidney.

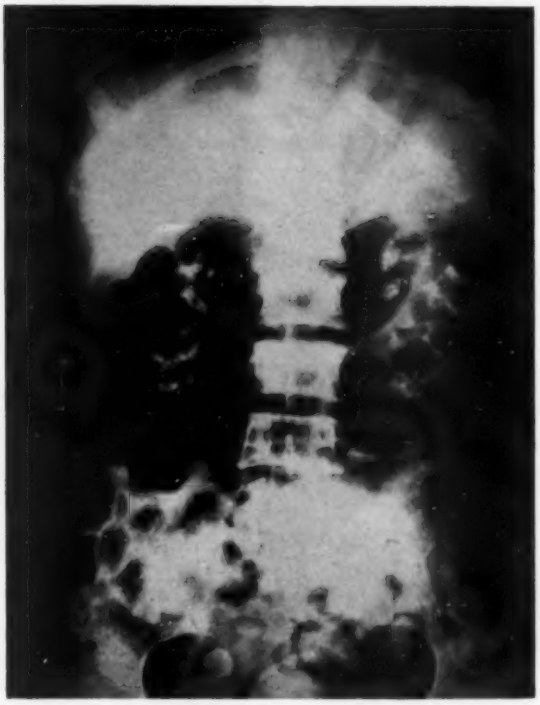

Fig. 3

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EARLY ESOPHAGEAL CARCINOMA

REPORT OF CASE

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THIS case is presented because it is believed to be one of the earliest of esophageal carcinoma ever diagnosed. The case was proved by biopsy and followed by successful resection.

The patient, a married white woman, aged fifty-five.

Symptoms. For several weeks before examination she had complained of a slight burning pain whenever she swallowed hot or cold liquids. The pain was referred to the epigastrium. There was no difficulty in swallowing and the patient was able to eat all foods without discomfort. There was no history of vomiting, bleeding or other gastric complaint. She suffered no loss of weight.

Because of the persistence of the pain for several weeks, it was thought that possibly the patient had swallowed a fish or chicken bone which had irritated the mucosa. She was therefore referred to me for a roentgen examination of the esophagus.

FIG. 1. Small defect can be seen about 3 inches above the cardia.

Roentgen Examination. Preliminary roentgenoscopy of the chest showed no abnormality. The patient was given a small amount of thick barium mixture. Roentgenoscopically no defect could be seen, the barium passing readily down into the stomach. Routine mucosal studies of the entire esophagus made with the patient in the recumbent position showed a small tumor mass about 3 inches above the cardia. It was reported as follows: "Roentgen examination of the esophagus with the aid of barium shows the following: There is evidence of a small tumor mass in the esophagus measuring about 1 inch in diameter, situated about 3 inches above the cardia. This causes no obstruction to the barium which passed readily down into the stomach. The exact nature of

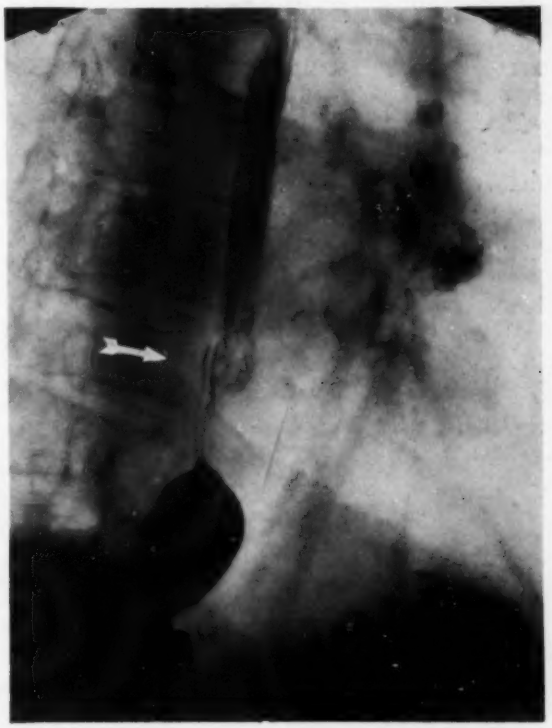

FIG. 2. Mucosal study outlining tumor.

this tumor cannot be stated from this examination; I believe it is probably malignant. Esophagoscopy is indicated."

The patient was esophagoscoped about ten days later. A small tumor mass was seen, as indicated by the roentgen examination, and a piece was removed for microscopic examination. The pathological report was squamous cell carcinoma.

The question of treatment was discussed at numerous consultations. Was surgery or radium and roentgen treatment indicated? The surgeon, Dr. John Garlock, thought that having diagnosed and proved such an early case of carinoma, palliation was not enough and that a cure should be attempted. It was believed, therefore, that surgery would give the best chance for permanent cure.

The patient had a preliminary gastrostomy which was followed ten days later by a complete resection. The transpleural route of approach was taken and the upper end of the esophagus brought out anteriorly. The complete tumor was removed. The pathological report follows:

"Specimen consists of a resected portion of the esophagus which measures 5.5 cm. long. Specimen has been previously opened. The adventitia of the esophagus appears to be covered by a thin layer of muscular tissue which shows no external evidence of any tumor invasion. Within the center of the specimen a small, somewhat soft mass is palpable. When the specimen is opened, one can see a flat sessile tumor mass situated 1.5 cm. from either end of the specimen. It is 2.0 cm. long and 1.4 cm. wide and is elevated from the surface of the mucous membrane approximately 1.0 cm. The mass is attached by a broad base to the mucous membrane of the esophagus which is freely movable up to the point of the tumor. The mass itself has a slight pinkish gray coloration and has a number of small surface depressions. Specimen fixed."

The immediate result of the operation is excellent. The patient is in good condition but it is, of course, too early to say anything about cure.

The fact that the tumor was removed *in toto*, that it did not extend through the mucosa and was freely movable over the muscularis and that over 1½ inches of normal wall beyond the tumor was removed, gives this patient a very favorable prognosis.

Addendum: At the end of two and one-half years this patient is working at her profession of teaching with no evidence of recurrence.

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A STUDY OF RADIATION PNEUMONITIS*

By HARRIET C. McINTOSH, M.D., *and* SOPHIE SPITZ, M.D.
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WITH the trend to higher voltages and greater protraction of fractional roentgen treatments in malignant disease, with increased knowledge of the amount of radiation required to sterilize certain types of cancer, visceral changes in greater number and severity are being increasingly disclosed. We are sometimes actually thrown upon the horns of the dilemma: whether it is better to try to extinguish the disease, or to risk extinguishing the patient. In planning treatment in which the beam of radiation enters the chest, it is of importance to know whether a given treatment will traumatize the lungs and pleura beneath. If it does, what discomfort or danger to the patient will ensue? Is the altered lung vulnerable in later years? The purpose of the present study is to offer concrete, and to a limited degree, quantitative answers to these questions.

Radiation pneumonitis has been discussed by numerous observers in the last fifteen years. Groover, Christie and Merritt[6] were the first to describe the condition in this country, followed shortly by Tyler and Blackburn,[15] Evans and Leucutia,[5] Davis,[1] and others. Desjardins[2] furnishes and extensive review of lung and pleural injuries from radiation up to 1932, including records of experimental work on animals. Karlin and Mogilnitzky[9] report further animal experiments. In 1934 Engelstad[4] of Oslo published a most interesting monograph in which are incorporated the results of irradiation of the lungs of 101 rabbits. His technique and dosages varied widely, with lung changes occurring inevitably beyond certain quantitative limits. This article also contains a bibliography of 161 titles. In 1934, at the Fourth International Congress of Radiology at Zurich, one of us[12] showed a small group of cases, correlating roentgen changes and measured lung tissue doses at standard depths. Some observers, notably Downs[3] and Kaplan and Bell,[8] find such changes infrequent or insignificant in their material. Other writers consider it a real hazard and especially advocate tangential application of rays (Hintze[7] and May[13]). Among the most interesting comments are those emanating from roentgenologists possessing supervoltage apparatus. Leucutia[10] discusses certain advantages of 500 kv. constant over 200 kv. (peak) in dealing with this problem of pneumonitis and fibrosis within the thorax. Ruggles,[14] working at 800 kv., has this to say: "We have given up the routine treatment of breast malignancy at high voltage because of the development of severe and disabling fibrosis of the lung coming on three to six months after the cessation of treatment and lasting for months or years. In the early cases we thought we might be dealing with tumor recurrences but the autopsies showed no evidence of carcinoma, only a massive fibrosis. It is accompanied by severe dyspnea and a racking dry cough, both of which last for months."

We will present here certain experiences and deductions evolved from 60 cases of carcinoma of the breast which also had adequate clinical and serial film follow-up. The clinical follow-up represented monthly visits the first year, and at least four times a year thereafter. Film examinations were made immediately before treatment, immediately after, and in the heavily irradiated cases, once a month for six months, and after that every three months for several years. In the lightly irradiated cases, two or more films were made in the first six months, and twice yearly thereafter. (A special fund was provided for patients unable to pay for this frequent film examination.)

* Read in part before the Section on Radiology of the American Medical Association, Atlantic City, N. J., June 7, 1937.

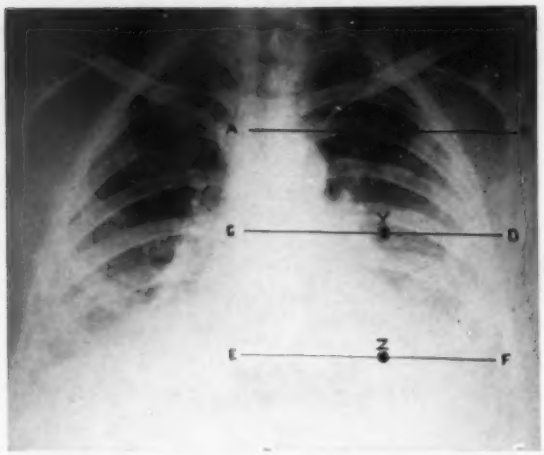

Fig. 1. Points for estimation of depth doses. Plane AB passes through articulation of first rib anterior; CD through third rib; EF through fifth rib. X, Y, Z represent points half way through chest at levels AB, CD, EF. X′ is one-third distance from front on same plane as X.

The series covers five years. It includes preoperative, postoperative, primary inoperable and recurrent cases, and variations in treatment extending from the old-fashioned 750–800 r per portal to fractionated treatments as high as 2,000 r to each of five portals. Our constant technique factors were 30 ma., 200 kv. (peak), 50 cm. distance., 0.5 mm. Cu and 1 mm. Al filter, intensity about 55 r per minute. These were used in all breast set-ups except anterior chest wall fields in postoperative cases where medium voltage was used (125–140 kv. (peak)), and small skin recurrences, for which we use 85–100 kv. (peak) and 1 mm. Al or no filter, the low voltage treatments being given at distances shorter than 50 cm. True tangential radiation, close to 180 degrees, was used in cross-firing bulky breasts in preoperative or primary inoperable cases, using two contralateral portals. Direct beams were used in cross-firing the axilla, usually through three portals. Recurrent disease was treated in various ways. Where angled beams were used, they are considered in our depth dose measurements. Our methods of estimating lung tissue dose was by standard phantom charts corrected for absorption in lung tissue, using the threshold erythema dose of MacComb and Quimby,[11] here considered as 500 r measured in air. The arbitrary points chosen for reporting and comparing lung tissue dosage were covered in a previous paper,[12] but are reviewed here in Figure 1.

The possible combinations taken into account in prognosticating probable lung effects, and often symptoms and outcome, are high, medium, and low lung tissue dose on old, middle aged and young women. For example, a high tissue dose on a young woman may give less lung and pleural change than a low tissue dose on an old arteriosclerotic, less at the time and less in permanent fibrotic residue. Also it must be remembered that the tissue dose, when computed in the center of the lung, as at points X, Y, Z, varies with the distance of these points from the surface, and that identical amounts of radiation measured in air, even with identical sized portals, may give variations close to 100 per cent as between a thin and a very fat woman. Other things being equal, a large dose of radiation produces more lung change than a small one, and in proportion.

For purposes of quantitative estimation of our results we decided upon the following system of grading lung changes as shown upon the roentgen film.

Grade I. Increase in bronchovascular markings and slightly decreased aeration over the treated area; or general homogeneous haze, interpreted as pleural reaction. Pleural changes temporary in Grade I.

Grade II. Either or both of above, with small, irregular, but discrete patches of peribronchial exudative consolidation. There may be elevation of the diaphragm.

Grade III. Confluent areas of exudation. Definite retraction of mediastinum to affected side and contraction of affected lung with elevation of diaphragm, even in the early months, before fibrosis has set in.

Grade IV. Extensive confluent exudative process with marked contraction of the lung, producing dense, almost complete consolidation of the treated area.

Careful measurement of lung tissue dos

was made in the majority of the cases. It was not possible in some, chiefly because of multiple series, where the time factor could not be estimated. To cover the whole group therefore, we evolved a somewhat rough classification into high, medium and low lung tissue dose. For the most part, the medium and low lung doses were either tangential or, if straight beam, were applied early in our series and would now be considered inadequate.

CLASSIFICATION OF DOSAGE

High lung tissue dose produced in general by more than 1,600 r (in air) to each of five portals in a thin or medium-sized woman, if much direct radiation into the lung. Measured readings range from:

CASE M. R.

5.0 threshold erythema doses at point x
6.5 threshold erythema doses at point x′
3.5 threshold erythema doses at point y
2.1 threshold erythema doses at point z

to

CASE J. S.

9.0 threshold erythema doses at point x
9.9 threshold erythema doses at point x′
6.1 threshold erythema doses at point y
3.2 threshold erythema doses at point z

This last was produced by heavy cross-firing in a case of recurrent disease after simple mastectomy, in a very thin woman.

Medium Lung Tissue Dose. Less than 5 threshold erythema doses at any given point. Typical cases give depth readings in the following range:

Case N. M.

3.5 threshold erythema doses at point x
3.8 threshold erythema doses at point x′
2.6 threshold erythema doses at point y
2.4 threshold erythema doses at point z

CASE B. S.

4.6 threshold erythema doses at point x
4.8 threshold erythema doses at point x′
3.6 threshold erythema doses at point y
3.2 threshold erythema doses at point z

Such doses have been produced by fractionated treatments of 1,600 r or less to four or five portals, in medium-sized women, and by considerably less in very thin women.

Low Lung Tissue Dose. One to 2 threshold erythema doses at any given point, produced by fractionated treatments up to 1,200 r, or a single massive dose of about 750 r to each of three or four portals.

While number of portals has little meaning without designating their size, this is automatically assessed by the lung tissue doses resulting.

CASES SHOWING LUNG CHANGES

Our material comprised 36 cases with positive roentgen changes. Seventeen cases in our series showed negative findings in the chest. Seven more had pulmonary metastasis. Three of these were believed to have both radiation change and malignancy, but as we have no autopsies on them, they are not classed with the group of 36 studied below. This material was scrutinized from three aspects: (1) age; (2) amount of lung tissue dose; (3) symptoms.

TABLE I

AGE DISTRIBUTION IN SIXTY CASES

Age	Positive Lung Changes	No Lung Changes	Metastasis	Total
Old	12	2	3	17
Intermediate	20	10	3	33
Young	4	5	1	10
Total	36	17	7	60

For our age classification, we considered women over sixty as "old," from forty to sixty "intermediate," under forty "young." The age distribution of our cases is seen from Table I. Taking those with positive lung changes we again classified them in Table II, according to both age and severity of reaction. A further breaking down of the figures in Table II is interesting. Of the 12 cases over sixty years of age, 8 showed Grade III or IV reactions, of which only 4 had high tissue doses, and 2 had as low as 1.5 T.E.D. at any given point. All 4 of those

Fig. 2. Case 1. Aged sixty-five. Three months after treatment. Lungs clear before and immediately after treatment.

with Grade 1 reactions had low tissue doses, and in all cases with low tissue doses showing lung changes, arteriosclerosis was demonstrated.

In the intermediate group, 20 cases in women forty to sixty years old, all Grade

Table II

THIRTY-SIX POSITIVE CASES CORRELATING AGE AND DEGREE OF REACTION

Age	Grade IV	Grade III	Grade II	Grade I	Total
Old	4	4	0	4	12
Intermediate	2	3	7	8	20
Young	1	1	0	2	4
Total	7	8	7	14	36

III and IV reactions arose from high tissue doses. Of the 7 cases with Grade II reactions, 1 had a high tissue dose, and 6 medium. Of 8 cases with Grade 1 reactions 4 followed medium tissue doses, 4 low dosage. In the young group the single Grade IV reaction followed an excessively high tissue dose, the Grade III reaction followed a high dose, and the 2 Grade 1 reactions followed high and medium doses respectively.

These findings are the basis for our belief that age and arteriosclerosis exert a definite influence on the reaction of lung and pleura to irradiation. An analysis of the 17 negative cases shows that all had low lung tissue doses except one, a woman of forty, and hence on the borderline of the young group. Even in the aged and arteriosclerotic group interesting variations appear. Case 1 (Fig. 2) shows a Grade III reaction in an elderly woman receiving over 5 T.E.D. in the center of the involved lung. The film was made about four months after treatment. Figure 3 shows considerable fibrosis and lung retraction two and a half years later. An autopsy on this case will be described in the pathological discussion. No carcinoma was found in carefully sectioned lung.

Figure 4, Case II, shows an even more extensive reaction in another old woman, who, however, received less than half of the lung tissue dose given to the preceding case. The reaction cleared more rapidly, however, as proved by interval films, and her two-year film (Fig. 5) shows little fibrotic residue, no elevation of the diaphragm, little retraction of the mediastinum. A certain amount of individual

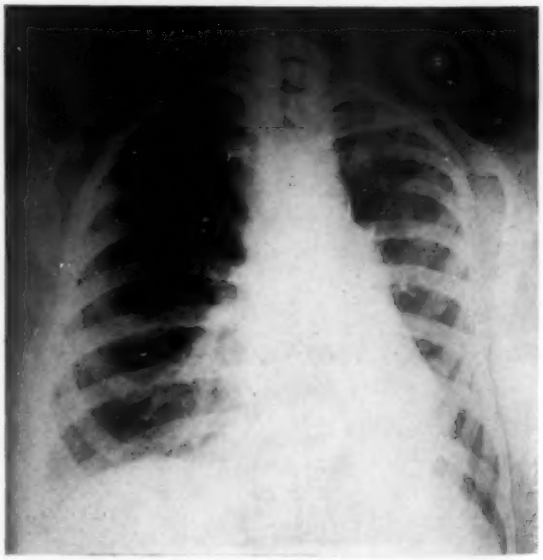

Fig. 3. Case 1. Two and a half years after treatment. Note partial clearing. Moderate amount of fibrotic residue with contraction of left lung.

variation cannot be accounted for. Both of these women were within two years of one another in age. The first had a broncho-pneumonic episode when her reaction was at its height, at about three months. The other had no symptoms or signs, but showed more lung change early, less lung change late.

CASES WITH SYMPTOMS

Of our 36 roentgenologically positive cases, 15 showed Grade III and IV reactions (see Table III). Of these 15, only 10 had any symptoms whatever. Of 21 cases showing Grade I and II pneumonitis, only 1 had a single symptom—cough—of brief duration. We may consider then that these milder changes in the lung are practically symptomless, clinically of no consequence, and found only when chest roentgenograms are taken frequently and in proper time relation to the end of treatment. This would explain why some roentgenologists, giving low lung tissue doses or taking infrequent films, do not discover such changes and state that they are not found. Also reports of autopsies have been described as negative for lung radiation changes, when no statement is made as to age of patient, how long after treatment, or how much lung tissue dose was given. The patient illustrated in Figures 4 and 5 has lived four years since treatment, but if she died, we should not expect to find radiation changes in her irradiated lung, though they were unmistakably present in the two-to-five-month period following her treatment.

We will consider now, from Table IV, the cases with symptoms. All eleven had cough. Five of these remained ambulatory throughout. Excluding the patient with lobar pneumonia who died, the symptoms in all diminished within four to six months, in some disappeared entirely. In only 2, both of which were cases where an existing

TABLE III

ANALYSIS OF POSITIVE CASES IN RESPECT TO SYMPTOMS

Radiation pneumonitis Grades III and IV.....	15
Number of cases in this group with symptoms..	10
Radiation pneumonitis Grades I and II.....	21
Number of cases in this group with symptoms..	1

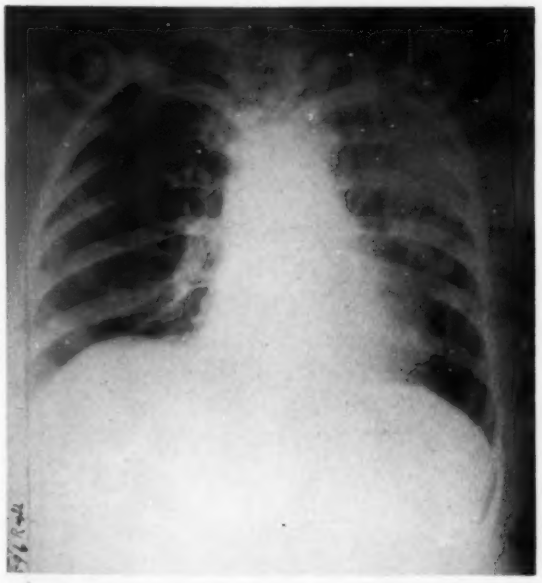

FIG. 4. Case II. Aged sixty-one. Two months after second cycle. Lungs clear at the beginning and end of treatment.

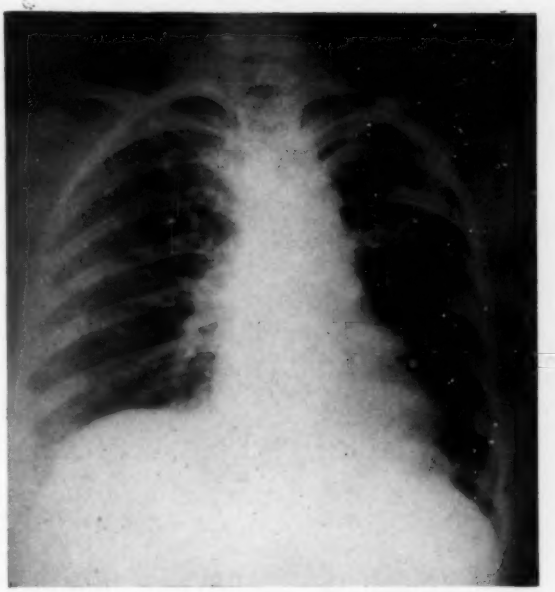

FIG. 5. Case II. Two years after treatment. Very slight residue of fibrosis. There has been no further change up to three years after treatment. Patient clinically free of disease at present.

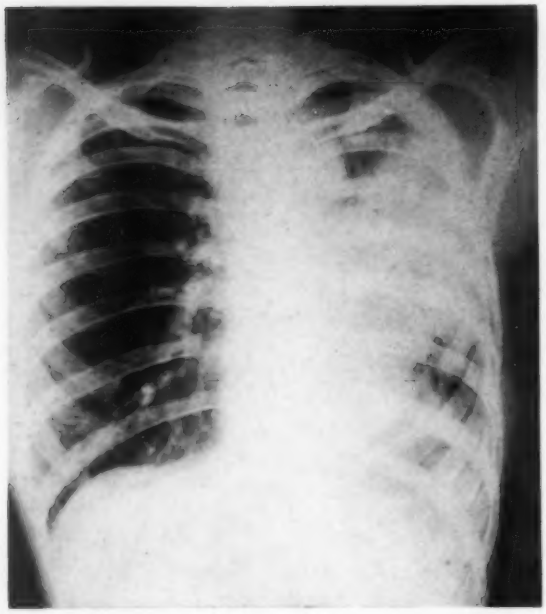

Fig. 6. Case III. Aged forty-nine. Three and a half months after treatment. Lungs were clear at beginning and end of treatment. Note extensive, confluent exudative process in treated area.

pneumonitis was mistakenly re-treated as metastasis, did the cough persist indefinitely. Five cases had a single acute episode of clinical bronchopneumonia, the attacks coming on from two weeks to three months after treatment. One case had a pneumococcus lobar pneumonia following exposure; its relation to irradiation is questionable. Although the bronchopneumonia cases all had high lung tissue doses, averaging over 5 T.E.D., the highest lung tissue doses we have ever given produced no symptoms whatever referable to the chest (Case III). This individual, referred to above as Case J. S., received 9.9 T.E.D. at point x′. She had no cough, pain, dyspnea, or fever at any time. Her lack of symptoms with such a dose seems unreasonable, and we have no satisfactory explanation of it. She was forty-nine years old, and hence in the intermediate group. With so much lung impairment, one would at least expect cough and dyspnea (Figs. 6 and 7).

Table IV

Symptoms found in eleven cases

Cough only		5
Cough with dyspnea		6
Cough with dyspnea and pain	4	
Cough with dyspnea and dysphagia	1	
Bronchopneumonia, single episode with recovery		5
Pneumococcus pneumonia with death (relation to irradiation questionable)		1

Wintz[16] and others have advanced the opinion that lung altered by irradiation is more vulnerable to subsequent infection. Our evidence is as follows: Of the 15 cases with severe pneumonitis, as judged by roentgenograms, 5 had bronchopneumonia as noted, which they survived. Only 1 of these cases had a second attack, and she was eighty-two years old, with advanced myocardial disease. None of the remaining 10 Grade III and IV cases, nor any of the 21 Grade I and II cases, 31 in all, have had pneumonia, in the periods between two and five years during which they have been followed. One case, classified as a Grade II, had a radical mastectomy two and a half months after treatment with an unusually long anesthetic of three hours, which she took well, with no postoperative pulmonary complications.

Fig. 7. Case III. Nine months after treatment. There is marked contraction of the lung, elevation of diaphragm, retraction of mediastinum.

DIFFERENTIATION FROM METASTASIS

The problem of differentiation between metastasis and radiation pneumonitis may be a source of acute anxiety to clinician and roentgenologist. If metastasis is present, palliative treatment may be thought indicated. If pneumonitis, more treatment is obviously undesirable, as illustrated by the following case.

CASE IV. This patient had had two cycles of postoperative irradiation of the breast at another hospital. Figure 10 shows the condition of the chest six months after the completion of these treatments. The condition was then believed to be metastasis from her previous breast carcinoma, and palliative roentgen treatment was administered. Figure 11 shows the condition five months later. Patient was at this time having pain, dyspnea and a harassing cough. Subsequent films up to the present, a period of four years, have shown slight recession of the process, and no development of metastasis, there or elsewhere. Patient is working as a journalist, and is clinically free of her original disease. Her only complaints are a chronic morning cough, and dysphagia at times, caused by stricture of the esophagus due to traction of adjacent fibrotic lung and pleura.

We have ourselves treated 2 other cases of pneumonitis erroneously, believing them to be metastasis. One of these has had considerable pain, and a distressing cough. Her symptoms have been somewhat alleviated by short wave diathermy, though the appearance of the films remains unchanged.

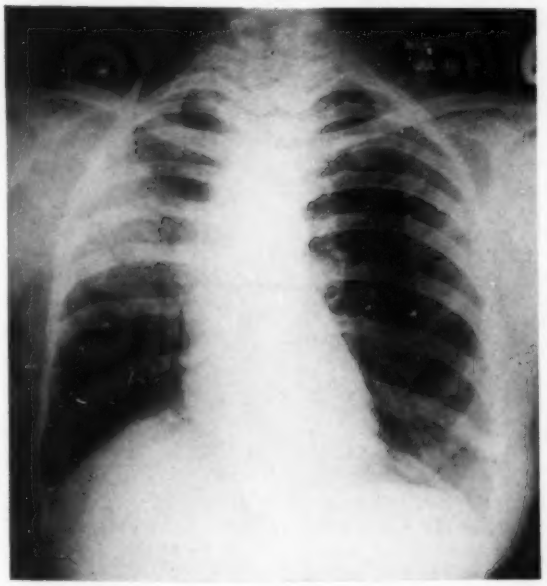

FIG. 8. Case IV. Aged forty-nine. Radiation pneumonitis mistaken for metastasis and treated.

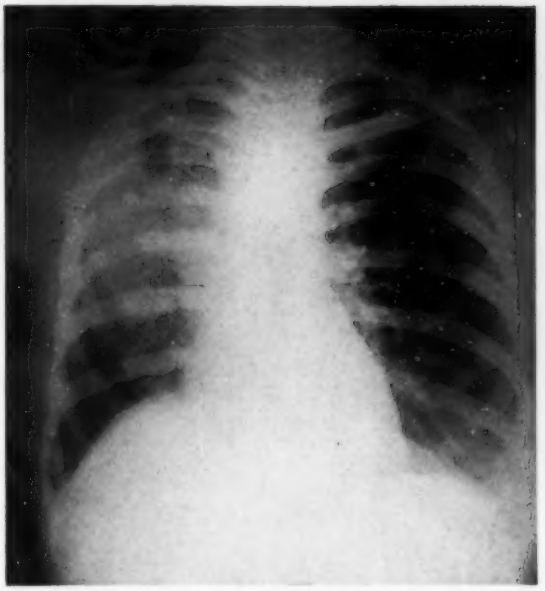

FIG. 9. Case IV. Five months later. Pneumonitis considerably increased.

To anyone having experience in viewing these radiation changes in the lung, the appearance is characteristic in the majority of cases. In some, diagnosis is difficult or impossible, especially when a single set of films is offered for decision, or when exact details of treatment, information on age, size, etc., are not available. But if the treatment factors are known, the lung tissue dose fairly high or the patient elderly, our experience inclines us toward waiting several months, with monthly films, to see whether the lesion recedes, increases, or remains stationary. Treatment of the type of metastasis which resembles radiation pneumonitis is so seldom of avail that waiting need not weigh too heavily on one's conscience, whereas additional treatment on damaged lung tissue is likely to produce undesirable symptoms or aggravate those present. The 3 mistakenly treated cases in our series have given the

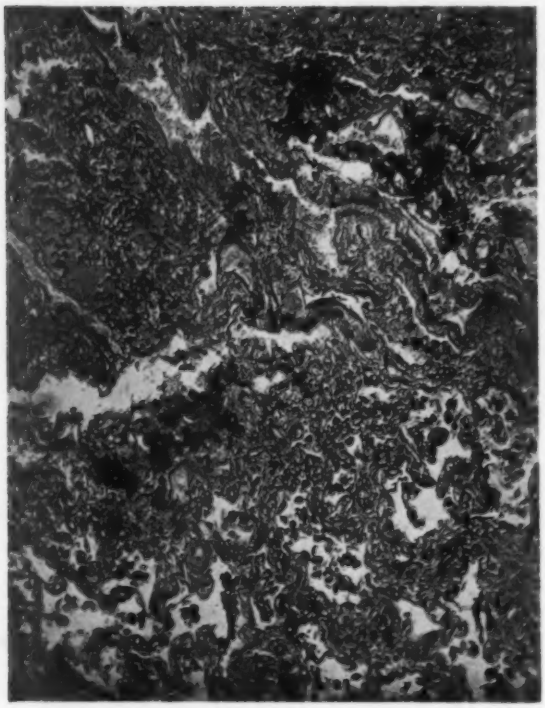

Fig. 10. Section taken from patient dying three and a half months after irradiation showing thickened alveolar walls and desquamation of alveolar epithelium.

most troublesome and long-continued symptoms of any of our material.

Downs[3] has pointed out that irradiation administered during the process of permeation of peribronchial and perivascular lymphatics by carcinoma results in fibrosis, and some persons have doubted whether a pure radiation change in the lungs exists. In answer to this latter contention one may say that it is not characteristic of lung metastasis to remain confined to a single area of treated lung, or to recede rather than increase without further treatment. Elevation of diaphragm, retraction of mediastinum, contraction of hemithorax on the treated side persisting for years are not characteristic of metastasis. Radiation changes are found in such diverse bodily structures as skin, intestine, bone. Why should we expect the lung to escape?

AUTOPSIES

Of the 36 cases in our series showing roentgen changes, 13 are now dead. Necropsy was performed on 6 cases, of which 2 were immediately postoperative deaths, occurring approximately eight weeks after conclusion of roentgen treatment; one died three and a half months after treatment, 1 one and a half years, and 2 after three years. In addition, 1 case, not included in the series, a male child aged five, treated for pulmonary metastasis from teratoma testis over a period of eight months, showed pulmonary irradiation changes of such interest that he is here included. From the study of the lungs of these cases, it has been possible for us to reconstruct the sequence of histopathological events and thereby to establish correlation with roentgen film evidence of pulmonary reaction to radiation.

The first case is selected from the 3 early deaths, and presents findings which we consider characteristic of early reaction.

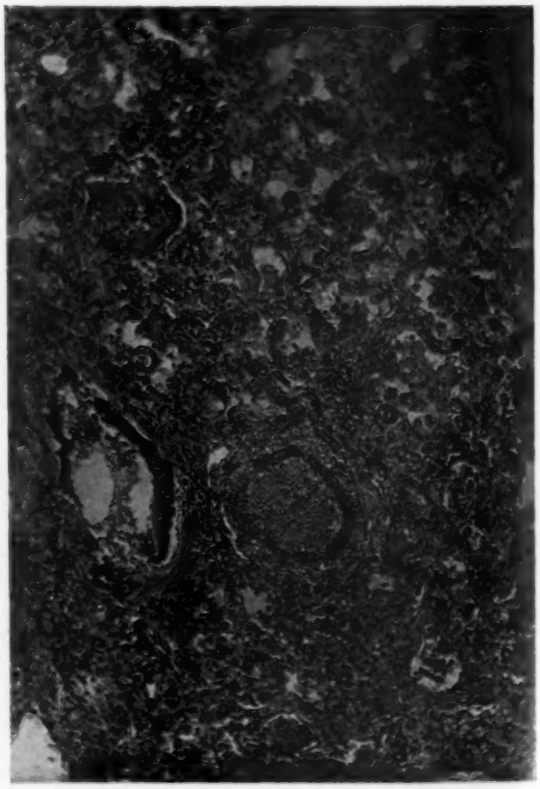

Fig. 11. Section taken from lung of child dying a end of protracted irradiation. Note similarity t Figure 10, with more definite increase in perivasc lar connective tissue.

Over the treated area (upper lobe) a partial diffuse consolidation was noted, while the lower lobe showed a definite lobar pneumonia. The lesion over the treated area was patchy and of definite peribronchial distribution. The untreated lung was normal. This patchy infiltration had been demonstrated in chest films before the onset of the lobar pneumonia from which she died. Histologically, the alveolar walls were generally thickened; the alveolar epithelium was desquamated into the air vesicles. Definite increase of perivascular and peribronchial connective tissue was present. The bronchial lymph nodes were hemorrhagic and in places necrotic. Scattered lymphocytes were found throughout (see Fig. 10). No carcinoma was found.

The most striking of these relatively early changes which we have encountered occurred in the case of teratoma testis following a protracted course of radiation treatment over both lung fields, with death

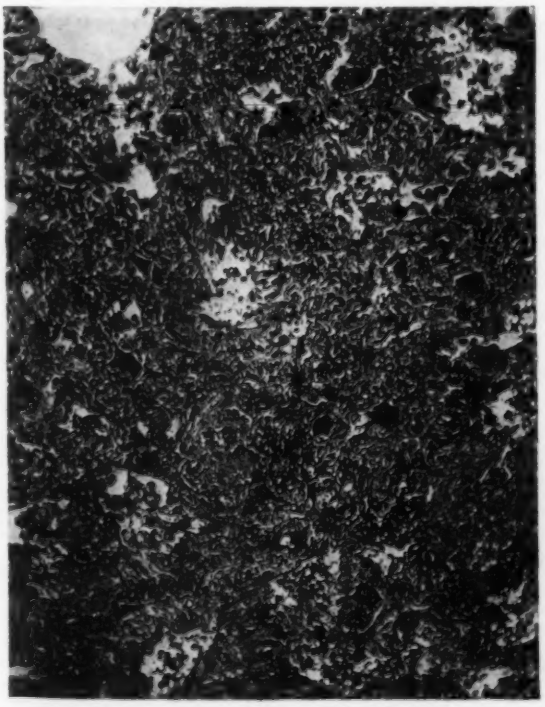

Fig. 12. Section from same lung as Figure 11 showing many alveolar macrophages, general increase in connective tissue, practically complete loss of aeration.

Fig. 13. Residual scar in Case 1 three years after treatment.

at the conclusion of the cycle. The lungs of this child seem identical with the lungs described by Engelstad[4] in experimental animals showing extreme reaction to large doses. The process is similar to the preceding although more intense and generalized, both lungs being affected alike (Figs. 11 and 12). The lack of air space is evident. The alveoli are packed with desquamated cells and alveolar macrophages are found in enormous numbers. The alveolar walls are increased in thickness. Bronchial epithelium in places is regenerating, and in other places is completely destroyed. Lymphocytes are scattered throughout although other leukocytes are rare. In summary, then, the picture presented by the initial pulmonary reaction to irradiation seems to be an intense catarrhal inflammation affecting all structures of the treated lung.

One case, a woman aged twenty-nine, reported in a previous article[12] as illustrating a Grade 1 pleural type of reaction which completely disappeared on subse-

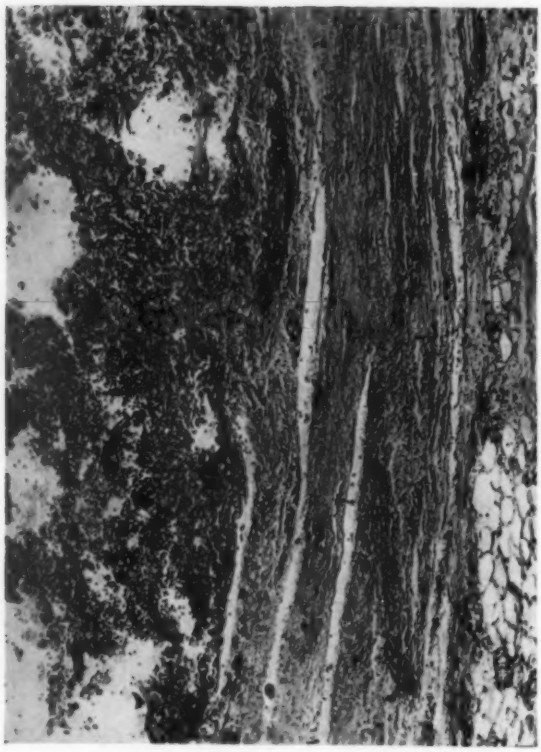

Fig. 14. Thickened, hyalinized pleura found in case receiving multiple treatments over three years.

quent films, came to autopsy one and a half years after roentgen treatment. Examination of the lungs revealed, as was expected, no evidence of radiation reaction in the lungs or pleura.

The lungs of the 2 remaining cases were studied three years after treatment. One, Case 1 mentioned above, had reaction classified as Grade IV originally, with roentgen evidence of a subsidence of the process and a residual permanent fibrotic lesion over the area of pneumonitis. The cause of death in this case was primary gastrointestinal cancer. At autopsy, a contracted scar was found in the treated area, which on section showed only dense fibrous tissue. No carcinoma was found (Fig. 13).

The last case is remarkable in that she presents our only necropsy evidence of participation of the pleura in this process. She had had repeated roentgen cycles over a period of three years for low grade recurrent disease. Free of pleural thickening by roentgen examination at the beginning of treatment, the lung of the treated side showed enormous thickening, as seen in Figure 14, in addition to both degenerative and reparative lesions as described above. This patient was eighty-one years old.

It is to be emphasized here that these lungs were carefully studied, with many sections of both the free and diseased lungs. In no case was the untreated lung found to be involved in the processes described. There was no evidence of the presence of carcinoma metastasis in any of the lungs examined (excluding the child with teratoma metastasis). Specific inflammatory disease, such as tuberculosis, was ruled out by special stains for the organisms.

Therefore from these studies, the damage produced by irradiation seems to be an inflammation of catarrhal type, which, if severe, heals with residue of permanent fibrous scar, the inflammatory changes resulting directly from the irradiation, and the permanent fibrosis resulting from repair of the damage.

SUMMARY

Sixty cases of mammary cancer receiving roentgen irradiation are presented for study of underlying lung changes, these changes being found in some degree in thirty-six. Observations are based on correlations between lung tissue doses and roentgenographic appearance and available autopsy material. Kilovoltage higher than 200 kv. (peak) was not employed on this material.

Lung changes are found proportional to the amount of radiation received in the lung, except that the lungs of elderly persons with arteriosclerosis are especially prone to pneumonitis and permanent fibrosis. In women under sixty years of age, unless showing premature senility, lung tissue dosage of less than 3.5 threshold erythema doses through any considerable part of the treated lung rarely produces changes demonstrable on the roentgenogram.

The milder grades of roentgen pneumonitis (Grades I and II) are symptomless and

clinically insignificant. Of fifteen cases of severe roentgen pneumonitis as judged by roentgenograms, ten, or 66 per cent, had symptoms, usually cough and dyspnea, found chiefly in the period between two and six months after treatment. In only two cases did genuine discomfort from cough persist beyond this time. Five cases had short bouts of clinical bronchopneumonia at the height of their lung reaction, with recovery in all. Only one had a second attack, a patient over eighty years of age. No cases of pneumonia have arisen in the other thirty-one roentgenologically positive cases.

Differentiation between irradiation pneumonitis and pulmonary metastasis is discussed.

The material from seven autopsies is described in part, and conclusions concerning the character of the reaction stated.

In conclusion, it should be pointed out that our lack of mortality and relatively low morbidity from irradiation pneumonitis with high lung tissue doses is not consistent with the experience of some other workers, who report prolonged periods of severe chest pain, cough and other symptoms, even deaths, resulting directly from lung damage. We believe the discrepancy can be at least partly explained by several factors. Our series is made up entirely of breast carcinoma. It does not include any primary lung or mediastinal conditions, which require the maximum of cross-firing and deep lung attack. Further, very large portals, 20×20 cm. or over, were never employed. More severe effects seem to come from these latter techniques, than from even our highest tissue doses, given peripherally or over smaller amounts of lung.

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EPITHELIOMA OF THE EYELIDS AND CANTHI*

REPORT OF A SERIES OF 324 CASES

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OF A TOTAL of 1,925 cases of epithelioma of the skin there were 324 cases, or 16.8 per cent, with involvement of the eyelids and canthi. This paper is based on a study of these 324 cases, treated by the authors (in their private practice of dermatology) over a period of twenty-three years. For the purpose of illustration there are included 4 cases from the dermatological service of the Cleveland City Hospital and 1 case from the dermatological service at Lakeside Hospital. Because of their rarity and also because of special indications for treatment, there is not included in this paper any consideration of malignant melanomas of the skin about the eyes, malignant lesions originating within the orbit, or those involving primarily the surface of the eyeball.

ETIOLOGIC FACTORS

1. *Precursor Lesions.* It is well recognized that changes in the skin of a precancerous nature usually precede the development of the actual tumor. These incipient pathologic processes do not always become malignant, but depend upon individual susceptibility, the patient's age, the condition of the skin, duration of the lesion, and so forth.

In 153, or 47.2 per cent, of the 324 cases, senile or seborrheic keratoses preceded or were present on other areas of the face. Keratoses usually develop as a result of changes in the skin due to long exposure to sunlight, the elements, and senescence. However, while advanced age is the most important factor in their development, yet in certain individuals, these changes may occur comparatively early in life, for example in the fourth and fifth decades.

Of great importance also is long continued irritation. In 57 cases, or 17.6 per cent, the cancer developed on areas subject to irritation by eye glasses. The majority of these occurred at the inner canthi, usually in those patients wearing nose glasses, while in others the irritation was produced on the lower lids by the pressure of the frames. In some instances this irritation was on areas where keratoses were located.

In 14 cases there was a history of trauma from other causes, and in 4 instances cancers developed on the site of old scars. Cancer at the bases of cutaneous horns was noted 4 times. Other causes less frequently noted were lesions of psoriasis, xanthelasma palpebrarum, pigmented fibrous nevi, xeroderma pigmentosum, and chronic infections, such as recurrent sties.

Other causes not seen by us in this series include radiodermatitis, lupus scars, irritation from oils, greases, pitch, tar, various chemicals, and metals.

In 66 patients, or 14.2 per cent, there were other malignant lesions present on the face, or they had been treated previously for skin cancer.

2. *Age and Sex.* Women are almost as prone to develop cancer of the eyelids and canthi as men. In this series, there were 155 and 169 cases respectively. In cancer of the skin in general we have found that males predominate in the proportion of about 3 to 2. Occupational hazards, especially those where exposure to sun and the elements is involved, doubtless account for this difference. In the region of the eye this is not as apparent, probably due to the somewhat protected character of the area (Table 1).

In a previous paper[1] it was shown in a series of 1,466 cancers of the skin and mucous membranes that 485, or 33 per cent, occurred in the seventh decade of life. In

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Table I

AGE INCIDENCE

Years	Cases
Under 21	1
21 to 30	2
31 to 40	22
41 to 50	47
51 to 60	85
61 to 70	94
71 to 80	54
81 to 90	17
Over 90	2

the present series, limited to the eyelids and canthi, 94 cases, or 27 per cent, occurred in this decade. In the thirty years between the ages of fifty-one and eighty inclusive, there were 234, or 72 per cent, of 324 cases.

Compared with population age statistics, it is seen that the older the individual, the more susceptible he is to the development of cancer in this region.

LOCATION OF LESIONS

The lower lids were the sites of the tumors in 164, or 50 per cent of the cases, while the upper lids were involved in 30, or 9.3 per cent. There were 86 lesions at the inner canthi, or 26.5 per cent, while at the outer canthi there were 21 cases, or 6.5 per cent. In 23 other cases there was extensive involvement invading two or more of the areas mentioned above. In most of these the cancer occupied the area of the lower lids and inner canthi. In others both lids and inner and outer canthi were affected, or there was extensive involvement of these areas, together with extension to neighboring skin; in a few instances there was involvement of bone, cartilage, conjunctiva, and the eye itself.

The lid margin and fibrocartilage are apparently extremely resistant to cancerous invasion, for it occurred only 24 times, or in 7.4 per cent of the cases.

It will be noted that the upper lids were involved in less than 1 of 10 cases, and that the inner canthus is the site of election more than four times as frequently as the outer canthus.

It is obvious that the upper lid is more protected than the lower, is the site of fewer keratoses, does not develop senile changes so readily, and is not subject to trauma from glasses and from their rims. Also the greater frequency at the inner canthus, as compared to the outer, is explained, at least in part, by the frequency of irritation from nose glasses.

DIAGNOSIS AND TYPES OF LESIONS

In this series of 324 cases, biopsies were performed, for diagnostic purposes or guidance in treatment, in 109, or approximately one-third of the cases. Properly performed, we believe that the taking of biopsies does not alter the prognosis and rarely produces a less satisfactory cosmetic result. The advantages to be gained undoubtedly outweigh any risks taken. In many instances biopsies were not performed because of the location of the lesion, for example those involving the lid margins, or small lesions at the canthi. In a few cases the tissue removed was too small for satisfactory examination.

Of the biopsied cases, 73 were basal cell epithelioma, and 7 were cystic basal cell in type. In other words, 73.4 per cent were of the basal cell or rodent ulcer type. Twenty were squamous cell and 9 were mixed baso-squamous cell types. Thus 27 per cent were of the more malignant type, which show a tendency to produce metastases. This percentage of the more malignant type is considerably greater than reported by other authors. Regaud, Coutard, Monod and Richard[3] reported a series of 58 cases of cancers of the orbito-palpebral region, in 46 of which biopsies were performed. Of these, 41 were basal cell, 4 squamous cell, and 1 was a special type. In 16 cases involving the lids and canthi, Laymon[4] found 15 of the basal cell type and 1 of the squamous cell type. Considering the frequency with which squamous cell carcinoma was found in our series and realizing the difficulties in differentiating the two types clinically, the importance of histologic examination of the tissue in questionable cases is apparent.

The clinical diagnosis of epithelioma of

the skin in the region of the eye is usually not difficult. In the localized forms, the lesion very often is a small indolent ulcerated nodule presenting a rolled or pearly border. Ulceronodular lesions the size of a quarter or larger may develop from the smaller ones. If not ulcerated, the growth is sometimes a small nodule a few millimeters to a centimeter or so in diameter, of about the color of normal skin, on the surface of which small capillaries are visible. On the lower lid the lesion is usually located a short distance from the lid margin. Carcinomas of the canthi are most frequently of the nodular type. Sooner or later they ulcerate and present the typically rolled, waxy, or pearly border. Less frequent is the superficial, flat, eroded type, which soon ulcerates, and enlarges slowly. They vary in size from a few millimeters at the start to the size of a quarter or half dollar. In another type the lesion early shows signs of infiltration, resulting in deep infiltrating ulcers, which, if untreated, may become extensive and involve the subcutaneous tissues, cartilage, conjunctiva, and bone.

In a number of instances there were plaque-like keratoses with infiltrated bases. Clinically it is not always possible to determine if a keratosis has undergone malignant degeneration. For this reason the removal of all keratoses and other precancerous lesions is strongly advised as a prophylactic measure.

Rarely does one see a depressed scar or morphea-like type which tends to spontaneous healing in the center, but which advances as a fine thread-like, pearly border. This type of lesion is often difficult to control.

The rate of growth of a lesion is a fair index of its malignancy. Squamous cell cancers generally grow faster than basal cell ones, but slow growth does not always indicate a low grade of malignancy.

CHOICE OF TREATMENT

The treatment of epitheliomas in the region about the eyes is in general the same as that for similar lesions on other areas of the skin. Various procedures and combinations of methods have been employed by most authors. Results obtained have been good, using various techniques. One operator will obtain splendid results by irradiation alone, while another will get similar results by the use of the cautery and curettage, or by electrosurgical procedures. One should probably use the method or combination of methods with which he has become the most skilled and with which satisfactory results have been obtained.

It is not our intention to consider the advantages of any one method over another, but to give an analysis of the results obtained by the various procedures used by us.

A few words as to general consideration are first in order. In treating lesions over the lids and around the canthi, the eyeball should be protected as much as possible. It is well known that the sclera is very resistant to irradiation, but the lens is more sensitive, and cataracts have been reported from irradiation, although in our experience this has never occurred. The lid itself is not sufficient protection to the eye, so that as a preliminary step to irradiation, we slip under the lid a sterile gold plated brass cup, 1 mm. thick, and having the concave shape of the eyeball. This shield is sterilized and coated with paraffin prior to use. Local anesthesia is used to prevent discomfort. In certain locations, such as the lower lid, it is possible to draw the lid down with long adhesive strips, which are fastened under the jaw, so that the direction of the rays is not in line with the eye.

In some cases the eye is protected by a lead shield fastened over the eye and upper lid, while in others the lesion is treated through a window cut into a piece of sheet lead 1 mm. thick, thus protecting the surrounding structures.

1. *Indications for Radium Treatment.* Radium was used by external or surface application, and interstitially by the use of radium needles or radon seeds. In this series of 324 cases, the surface application of radium alone was used in 41 cases. In another group of 73 cases, the surface appli

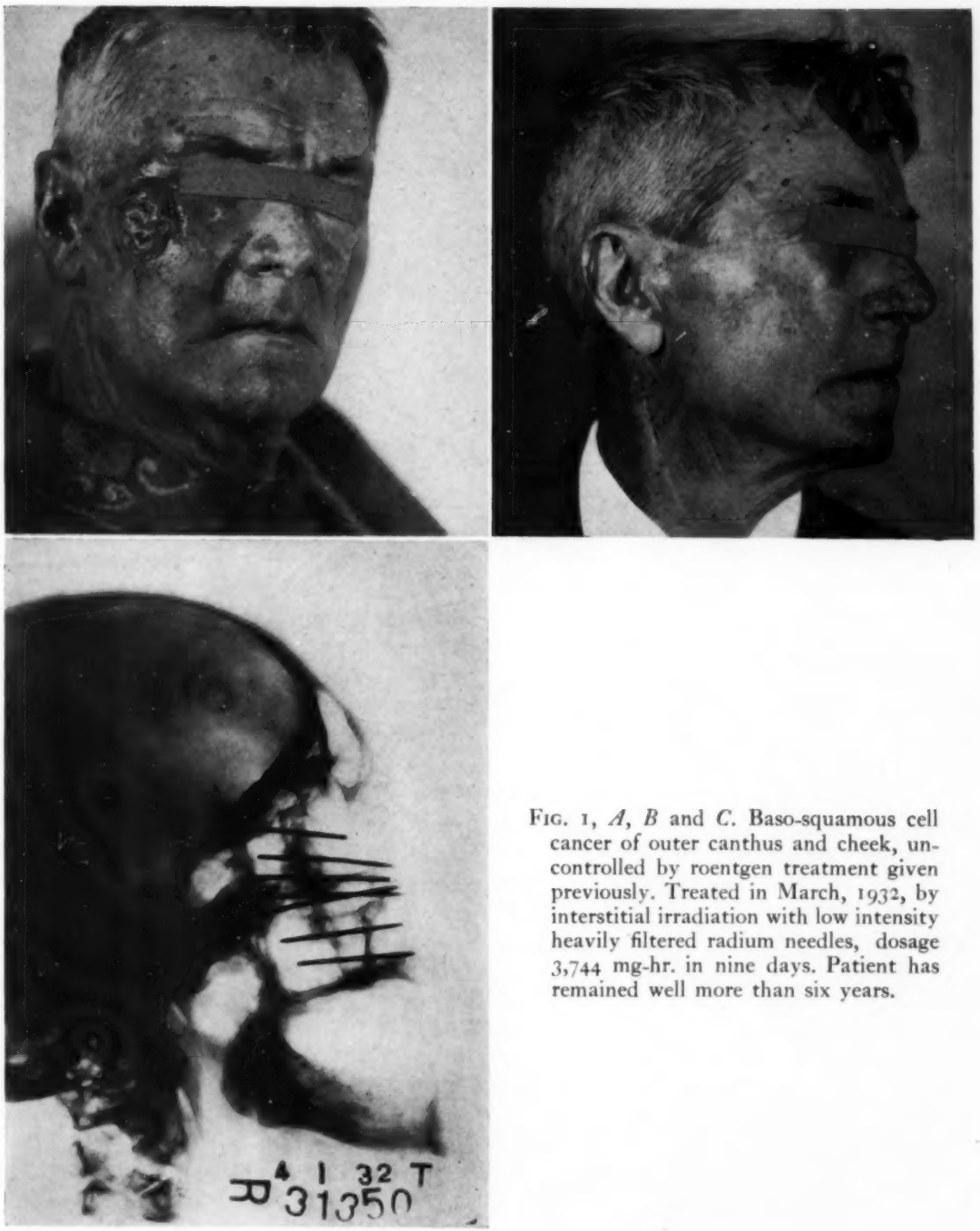

FIG. 1, *A*, *B* and *C*. Baso-squamous cell cancer of outer canthus and cheek, uncontrolled by roentgen treatment given previously. Treated in March, 1932, by interstitial irradiation with low intensity heavily filtered radium needles, dosage 3,744 mg-hr. in nine days. Patient has remained well more than six years.

cation of radium was immediately employed after the cautery, curettage, or electrodesiccation had been used. The radium thus used consisted of a 50 mg. tube screened by 1 mm. of silver and 10 mg. radium needles screened by 0.5 mm. of iridium. Several of these needles are arranged in a brass plaque, the number depending upon the size of the lesion. A half strength 10 mg. radium plaque using various kinds and thicknesses of filters was used in but a few cases.

Since 1932 we have treated 8 cases by interstitial irradiation with low intensity,

Fig. 2, *A* and *B*. Epithelioma of the outer canthus and temple of five years' duration in a woman aged eighty-seven. It was treated in May, 1936, by filtered roentgen rays. Approximately 800 r was given at two-days intervals for a total dosage of 6,600 r. Healing required three months. Patient was last seen on April 12, 1938, with no evidence of recurrence. Treated by the Departments of Dermatology and Radiology of Lakeside Hospital.

heavily filtered radium needles by the technique we have described in previous papers.[1,2] In general, this method was used in the more extensive infiltrated or ulcerated lesions that had been uncontrolled or had recurred following other types of therapy. These needles can be used for lesions involving the lid margins, apparently without danger to the eye itself, although sufficient time has not elapsed to finally answer the question (Fig. 1).

2. *Indications for Roentgen Treatment.* Roentgen therapy was employed in 11 cases, using a single hyperintensive treatment. The procedure consists of giving from 1,000 to 1,500 r, unfiltered, with a margin of about 3 mm. of skin surrounding the lesions, followed immediately by an additional dose of 400 to 800 r, using a filter of 3 mm. of aluminum, and increasing the margin exposed to about 1 cm. The factors were 133 kv., 5 ma., and 10-inch distance.

In 99 cases this method was used immediately following the use of curettage, electrocautery, and electrodesiccation, with excellent results.

Since 1933, sixty-five cases have been treated by a modified Coutard technique using unfiltered roentgen rays. In a few of these cases a filter of from 1 to 2 mm. of aluminum was used. The method consists of giving from 800 to 1,000 r every second day for a total of 3,200 to 6,000 r. When unfiltered radiation was employed, the following factors were used: 100 kv., 5 ma., and 10-inch distance. In the filtered radiation the same factors were used with the exception that the voltage was increased to 133 kv. In 10 of these cases curettage and electrocautery or electrodesiccation

Fig. 3, *A* and *B*. Basal cell epithelioma of outer canthus of several years' duration in a woman aged sixty. Treated in August, 1935, by unfiltered roentgen rays, a dose of 1,000 r being given every second day for a total of 4,000 r. Last seen on January 12, 1937, with no evidence of disease. *A*, August 24, 1935; *B*, October 8, 1935. Treated by the Departments of Dermatology and of Radiology of the Cleveland City Hospital

Fig. 4, *A* and *B*. Xeroderma pigmentosum in a girl, aged seventeen, showing squamous cell epitheliomas of inner canthus and cheek. Treated in October, 1937, by unfiltered roentgen rays. Each lesion received 2,000 r at two-day intervals for a total of 6,000 r. Note scars on nose, other cheek, and forehead, resulting from other malignant lesions treated over a period of ten years.

was employed, preceding the irradiation. In general, the results have been best with the Coutard method.

By this technique advantage is taken of irradiating the cancer cells during periods of mitosis, when they are most radiosensitive. Also it is possible to deliver a larger total dose without producing a radiodermatitis than if a single hyperintensive dose is used (Figs. 2, 3, 4, 5 and 6).

Case 1 (Fig. 2). C. S., female, German, aged eighty-seven, developed an epithelioma on the site of a senile keratosis at the outer canthus of the left eye. When seen on May 18, 1936, she stated that it had been growing slowly over a period of five years. Previous therapy had consisted only of applications of ointments. On examination the lesion was 4.5 by 6 cm. in size. It was crusted, deeply ulcerated, with rolled, pearly edges, and not movable on the underlying tissues. Treatment consisted of roentgen

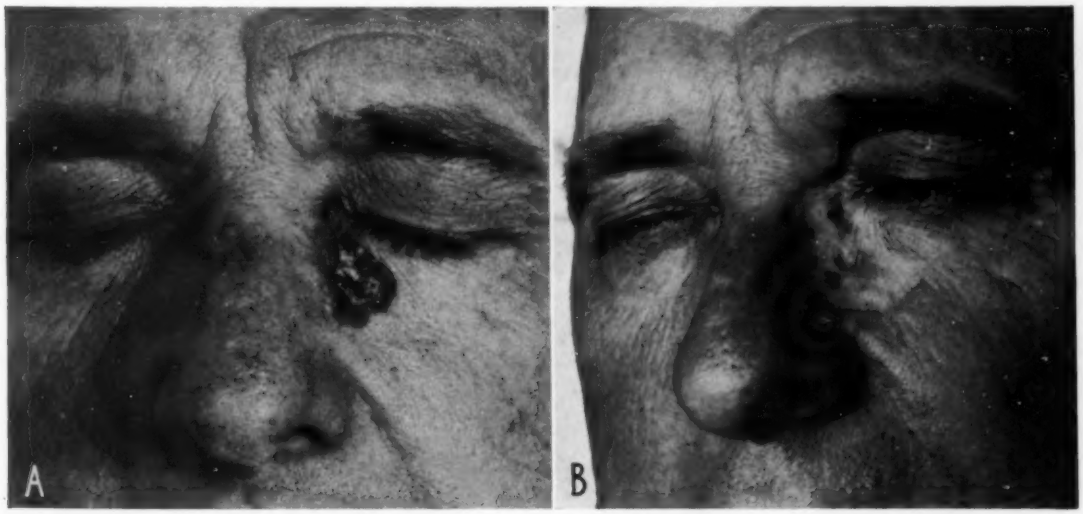

Fig. 5, *A* and *B*. Basal cell epithelioma of inner canthus and lower lid of several years' duration in a man aged forty-eight. Treated by unfiltered roentgen rays, a dose of 1,000 r being given every two days for a total of 5,000 r. *A*, March 13, 1937; *B*, May 20, 1938. There has been no evidence of recurrence. Treated by the Departments of Dermatology and Syphilology of the Cleveland City Hospital.

Fig. 6, *A* and *B*. Basal cell epithelioma of four months' duration in a woman aged sixty. Treated in October, 1934, by unfiltered roentgen rays, a dose of 1,000 r being given every two days for a total dosage of 3,000 r. *B* was taken on May 20, 1938, and shows no evidence of disease and no ectropion. Treated by the Departments of Dermatology and Radiology of the Cleveland City Hospital.

therapy by the Coutard method. Doses averaging about 800 r each were given every two days for a total of 6,600 r. Healing required about three months. When last seen on April 12, 1938, there was no evidence of recurrence. The result was unusually good. The factors were 100 kv., 2 mm. Al filter, 5 ma., 25 cm. distance. (This case was from the Departments of Dermatology and Roentgen Therapy, Lakeside Hospital.)

3. *Indications for Electrocautery, Electrodesiccation, and Curettage.* For small lesions the electrocautery or electrodesiccation followed by curettage is often sufficient. The curette is a most valuable aid in removing the destroyed tissue, and helps to determine the extent of the lesion. It should be used carefully, so as not to penetrate the subcutaneous tissue. Employed in this manner, the resulting scar is minimal and the cosmetic result is splendid. Twenty-one cases were so treated (Fig. 7).

As indicated before, these procedures are most often used in conjunction with irradiation. Their use is indicated also in those instances in which biopsies are taken.

Fig. 7, *A* and *B*. Basal cell epithelioma involving two-thirds of the margin of the lower lid. Had recurred following roentgen treatment in 1926. Treated in November, 1928, by curettage and electrodesiccation. No evidence of recurrence on May 10, 1938.

CAUSES OF FAILURE

1. *Effect of Previous Treatment.* In 79 of our cases a history of previous treatment was obtained. In 30 of these roentgen rays or radium had been used. Usually the doses were too small and generally inadequate. In 12 cases recurrence followed surgical excision. The electrocautery had been employed in 11 instances, electrolysis in 9, and caustics, including cancer pastes, had been ineffective in ten.

An attempt was made to determine the effect of previous treatment on the curability of the lesion. It was found that of 19 cases in which failures or relapses occurred, previous treatment had been given in 9, or almost 50 per cent. In other words, in the group of 79 cases, or approximately 25 per cent of the total series, about 50 per cent of the failures occurred. Therefore, in our experience failure from subsequent therapy is nearly twice as frequent in those patients who have received previous treatment.

2. *Radioresistance.* Squamous cell cancer is less radiosensitive than basal cell cancer. Failure to recognize this may result in insufficient dosage and failure. In those cases which have recurred following previous irradiation, cautery, caustics, or surgical excision, cancer cells are often located in poorly vascularized scar tissue, which renders them resistant to further irradiation. In such cases radioresistance is lessened by the Coutard technique of using roentgen rays or by the method of prolonged interstitial irradiation with the low intensity radium needles (Fig. 1).

CASE II. Mrs. I. S., aged seventy-eight, had received eight roentgen treatments for a cancer on the side of the nose in 1920. A recurrence was noted a few months later. The involved area slowly enlarged, and during the following sixteen years she applied only ointments. When first seen by us on April 8, 1937, the lesion involved the greater portion of the right side of the nose, and had infiltrated the skin in the region of the inner canthus. The following treatment was given: The area was divided into three parts, each part being given unfiltered roentgen radiation, consisting of doses of 1,000 r, every two days for a total of four treatments, or a total dosage of 4,000 r. When observed on March 23, 1938, there was no evidence of recurrence.

3. *Insufficient Dosage.* Inadequate dosage is the commonest cause of failure in cases treated by irradiation. In some, however, there was recurrence at the border of the lesion, indicating too close screening of the lesion (Fig. 1).

4. *Extensive Involvement.* Those patients in whom extensive involvement has resulted from neglect or inadequate treatment are sometimes found to have deep, infiltrated, ulcerating lesions, involving bone, tarsal cartilage, and occasionally the conjunctiva. The eyeball may be involved following that of the bulbar conjunctiva. Extension from the inner canthus usually precedes it, and the periorbital loose cellular tissue becoming involved results in fixation of the eyeball. Enucleation or exenteration of the orbit is necessary along with extensive removal or destruction of all diseased tissues. Failure to cure is not surprising in such cases. There were 3 such instances in our series.

CASE III. Mrs. M. S., aged forty-four, had had a sore at the outer canthus of the right eye for six years. She had been treated with cancer pastes and caustics. When seen in January, 1928, there was an indurated ulcer involving two-thirds of the margin of the lower lid, the outer canthus, and about one-third of the margin of the upper lid. The lesion was roughly 1 by 2.5 cm. in size, and histologically was baso-squamous cell in type. Following a single hyperintensive dose of roentgen rays consisting of 800 r, unfiltered, and 600 r, filtered, followed by the surface application of 125 mg-hr. of radium, the process was uncontrolled. In July, 1928, the eyeball was enucleated and the area treated by electrocoagulation. In June, 1929, a surface application of radium was given to an area of recurrence—a dose of 250 mg. being given after destroying the area by electrocoagulation. In February, 1930, there was a further extension involving the malar bone. The area, including the involved bone area, was surgically excised. In May, 1932, there was an

Fig. 8, *A* and *B*. Squamous cell epithelioma of lower lid in a man aged eighty-six. Treated in April, 1930, by a combination of a single hyperintensive dose of unfiltered and filtered roentgen radiation and surface application of radium. *B*, taken August 19, 1930, shows lesion healed. Patient returned in February, 1931, with extensive inoperable metastases to preauricular and cervical nodes. Died in September, 1931.

extensive recurrence involving the tissues of the orbit, the maxillary sinus, and the nose. Following surgical section of the fifth and ninth nerve roots to control pain, the patient died of pneumonia.

Had the more recently developed methods been used at the start, for example the Coutard technique of roentgen therapy, or interstitial irradiation with low intensity radium needles, according to the technique of Cade and Regaud, and that later used by us, the chances of recovery, we believe, would have been greatly increased.

RESULTS

Of the 324 cases reported in this study, 193 were followed for from six months to ten years or more. In this group there were 12 relapses, or 6.2 per cent, leaving 181, or 93.8 per cent, possible permanent cures. There were 70 patients who have been observed longer than five years with one relapse, or possible permanent cure in 98.3 per cent. Relapse after five years is rare in our experience. Twenty-one patients were observed over a period of three years with no relapses, while in 38 followed for one year there were 3 relapses, or 8 per cent of failures.

In a study of 644 cases of epithelioma of the skin, MacKee[5] found that 36 had recurrences. Twenty-one, or 58 per cent, of these occurred in less than a year. In our series there were 19 recurrences, of which 12, or 63 per cent, manifested themselves in less than one year. This group of 12 relapses was seen in 124 patients observed for from one month to eleven months, making possible permanent cures in only 90 per cent.

There were 33 patients who failed to return following completion of their treatment. This leaves 291 cases in whom 19, or 6.5 per cent, recurrences were observed. Therefore in this group, which includes all the cases which were followed for one month or longer, there were 272, or 93.5 per cent, possible cures. Of the entire series of 324 cases here reported there were 6 known deaths attributable to cancer (Fig. 8).

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A STATISTICAL STUDY OF THE EFFECT OF ROENTGEN RAYS ON WOUND HEALING*†

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PREVIOUS investigations on the effect of irradiation on healing wounds have employed methods of gross and microscopic comparison of irradiated and control tissues. No satisfactory quantitative study of healing has been applied to irradiation experiments. A simple quantitative method of investigating healing of wounds by measurement of tensile strength has been described by Howes, Sooy and Harvey.[7] In the present study the tensile strength method was used in an attempt to obtain more accurate information as to the effect of roentgen irradiation on wound healing.

METHOD

In the present investigation adult, male, albino rats were used. Two separate ventral skin incisions, 4 cm. in length, were made on each animal. The wound edges were approximated with black silk. One of the wounds was exposed to radiation through a 4×1 cm. aperture in a lead shield which adequately covered the animal. Roentgen rays were produced by a full wave, mechanically rectified generator at a tension of 95 kv. (peak). With a Coolidge tube, 4 ma. of current, 40 cm. focal skin distance, and no added filter, the output measured in air was 60 roentgens per minute.

The following experiments were performed using 409 animals:

1. One hundred and twenty-eight wounds received 300 r immediately after operation.
2. Fifty-one wounds received 1,020 r immediately after operation.
3. Fifty-seven wounds received 1,800 r immediately after operation.
4. Sixty-five wounds received 1,800 r twenty-four hours after operation.
5. Fifty-four animals received 1,800 r to one of the operative sites one week before operation.
6. Fifty-four animals received 1,800 r to one of the operative sites three weeks before operation.

Control and irradiated wounds were excised at intervals of five, ten, twenty, thirty, forty, fifty, and eighty days following operation and the tensile strength measured with a thread tester and recorded in grams per square millimeter in each of the six experiments. Four to 22 animals were used for each observation. Animals with infected wounds were discarded.

A curve of the tensile strength of healing wounds was constructed for each of the experiments. The control wounds of all groups were averaged for all observations and were used to construct the normal tensile strength curve.

Because small series of observations cannot be analyzed accurately by the usual method of calculation of standard deviation, the statistical significance of the results was determined according to Fisher's method of analysis of small series of observations.[2] This takes into account the number of observations, the difference between experimental and control means, and the variation between individual observations.

The value of "t" is derived from the mathematical formula,

$$t=\frac{\bar{x}-\bar{x}^1}{\sqrt{\frac{\Sigma d^2}{N_1+N_2-2}}}\times\sqrt{\frac{N_1\times N_2}{N_1+N_2}}.$$

From tables compiled by Fisher the significance of observations is expressed in terms of P which is the probability that if there were no real difference between experimental and control groups a value of "t" would be obtained which would exceed the observed value of "t."

Values of P exceeding 0.05 are not considered significant.

In addition to the significance of individual observations the trend of the observations is taken into consideration in the evaluation of the results. Thus, although one or two single values are not significant the experiment as a whole may be considered so.

In addition to the tensile strength determinations histological sections of control and irradiated wounds were taken at intervals of four, five, six, eight, ten, twenty and fifty days after

* From the Department of Surgery, Section of Radiology, Yale University School of Medicine.

† The expense of this investigation was defrayed by Davis and Geck, Inc.

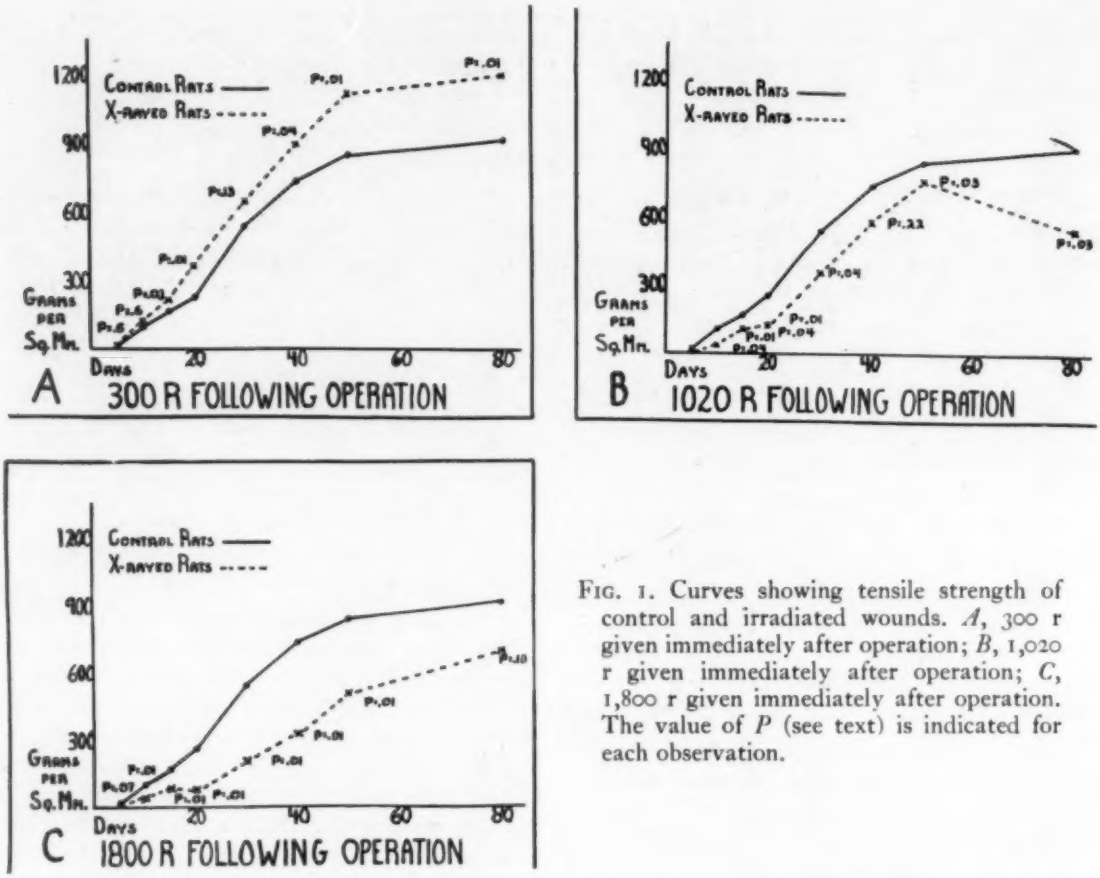

Fig. 1. Curves showing tensile strength of control and irradiated wounds. *A*, 300 r given immediately after operation; *B*, 1,020 r given immediately after operation; *C*, 1,800 r given immediately after operation. The value of *P* (see text) is indicated for each observation.

operation. Because of foreign body reaction to the silk sutures during the first ten days of healing, many of the sections were considered unsatisfactory for histological study and were supplemented by sections of wounds which had been closed with silver skin clips. The histological material was studied with Dr. Robert Tennant of the Department of Surgical Pathology.

RESULTS

1. *Effect of Exposure of Wounds to 300 r Immediately following Operation.* Irradiated wounds in this series exhibit a significant increase in tensile strength as compared with the controls with the exception of the five and ten day periods (Fig. 1*A*). A relatively large number of animals was used as a result of repeating the experiment a second time. The curve represents an average of both groups which individually showed essentially the same characteristics.

Histological study of wounds irradiated with 300 r shows no evidence of increased fibroplasia or cellular reaction. Epithelization is complete before four days in both the control and irradiated wounds (Figs. 3*A* and *B*). At this time there is beginning growth of fibroblasts across the wound and moderate cellular reaction in the deep layers. The tissues are slightly swollen and edematous. At six days there is increased fibroblastic activity and a wider zone of cellular reaction in irradiated and control wounds (Figs. 4*A* and *B*). At eight days newly formed hyalin connective tissue forms a broad scar (Figs. 5*A* and *B*).

Gross examination reveals no perceptible difference between the control and experimental wounds at any time.

2. *Effect of Exposure of Wounds to 1,020 r Immediately after Operation.* The tensile strength of wounds receiving 1,020 r is significantly decreased as compared with control wounds (Fig. 1*B*).

Microscopic examination of these

wounds reveals less cellular reaction in subcutaneous layers and delayed appearance of fibroblasts as compared with the controls. At ten days the connective tissue scar is less mature than in the control wounds.

Retardation of healing and temporary epilation is apparent from gross examination. No increased incidence of infection is noted in this group.

3. *Effect of Exposure of Wounds to 1,800 r Immediately after Operation.* The wounds of the group receiving 1,800 r immediately following operation show significant decrease in tensile strength. The decrease is rather marked (Fig. 1*C*).

Histological study shows retardation of connective tissue proliferation (Figs. 3*C*, 4*C*, 5*C*, and 6*B*). Degenerative changes are seen in the subcutaneous tissues after ten days. Hair follicles are small and few in number with no evidence of regeneration up to sixty days after irradiation. Epithelial growth is slow during the early days of healing and cellular reaction in the deeper layers is less marked than in the control wounds. Considerable edema is noted in the deep layers.

Gross examination of the wounds shows epilation which is persistent for at least three months. Reddening of the skin appears in four days and lasts for from ten to twelve days. Skin ulcerations and wound infection occur frequently.

4. *Effect of Exposure of Wounds to 1,800 r Twenty-four Hours after Operation.* In this series the irradiated wounds show no significant decrease in tensile strength as compared with the control group (Fig. 2*C*).

No histological sections were made in this group.

5. *Effect of Exposure of Skin to 1,800 r One and Three Weeks before Operation.* The wounds of the two groups which received 1,800 r to the skin before operation show a

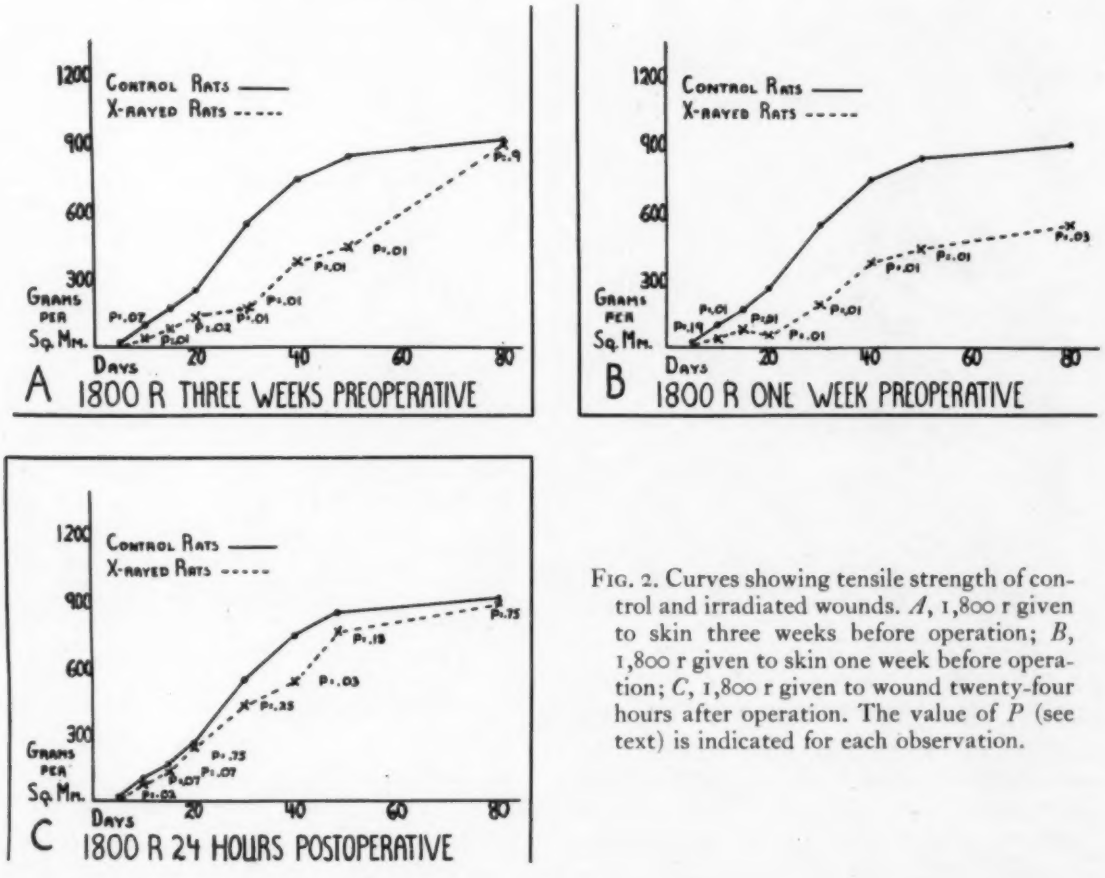

Fig. 2. Curves showing tensile strength of control and irradiated wounds. *A*, 1,800 r given to skin three weeks before operation; *B*, 1,800 r given to skin one week before operation; *C*, 1,800 r given to wound twenty-four hours after operation. The value of *P* (see text) is indicated for each observation.

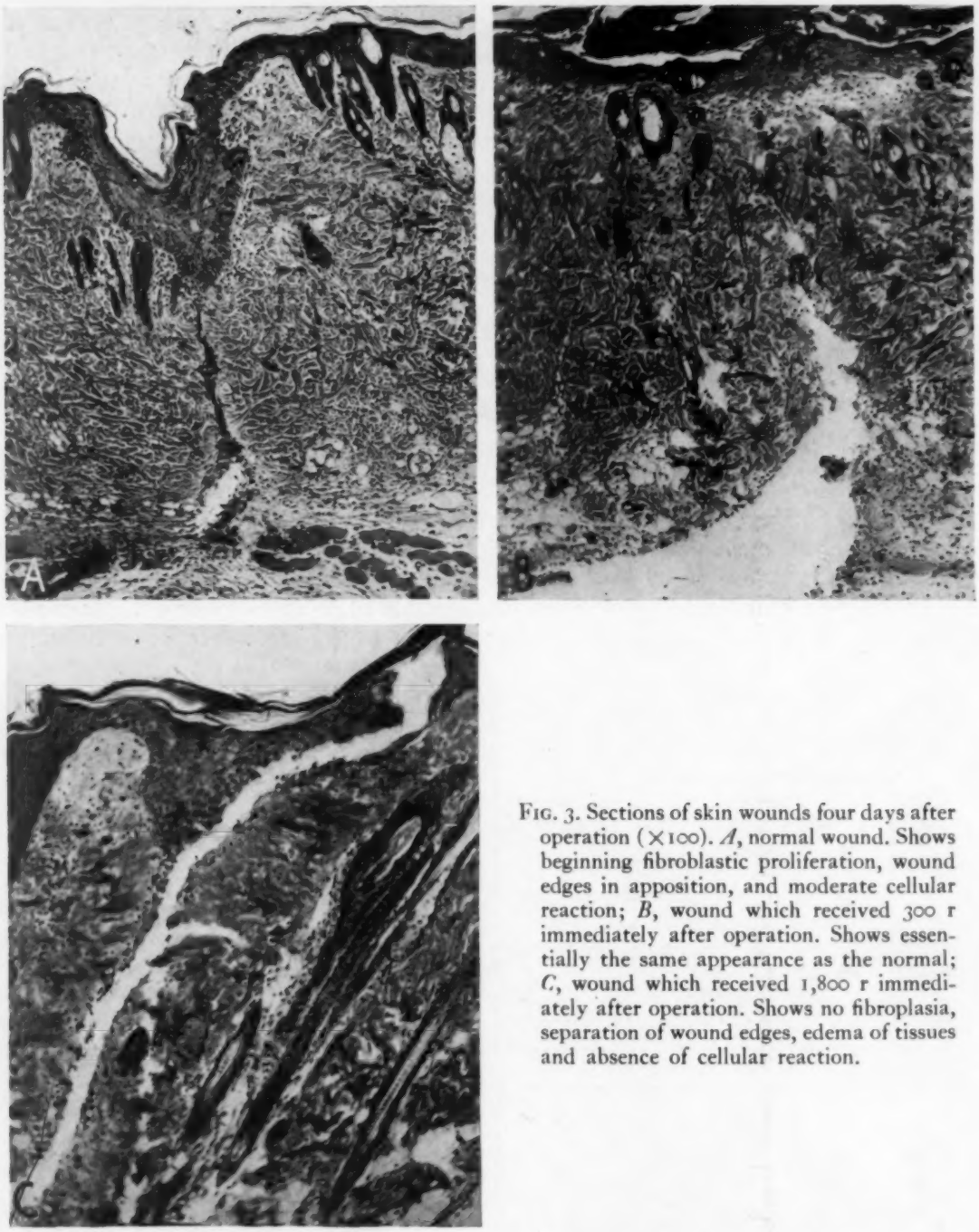

Fig. 3. Sections of skin wounds four days after operation (×100). *A*, normal wound. Shows beginning fibroblastic proliferation, wound edges in apposition, and moderate cellular reaction; *B*, wound which received 300 r immediately after operation. Shows essentially the same appearance as the normal; *C*, wound which received 1,800 r immediately after operation. Shows no fibroplasia, separation of wound edges, edema of tissues and absence of cellular reaction.

significant decrease in tensile strength up to eighty days after operation (Figs. 2*A* and *B*). The changes noted are of approximately the same magnitude as those seen in wounds irradiated with 1,800 r immediately after operation.

The histological and gross appearances of the wounds correspond to those observed in the group which received 1,800 r immediately after operation (Figs. 6*C* and *D*).

DISCUSSION

Tensile strength is a fundamental physiological property of tissue which can be considered a function of wound healing. The advantage of using a property which

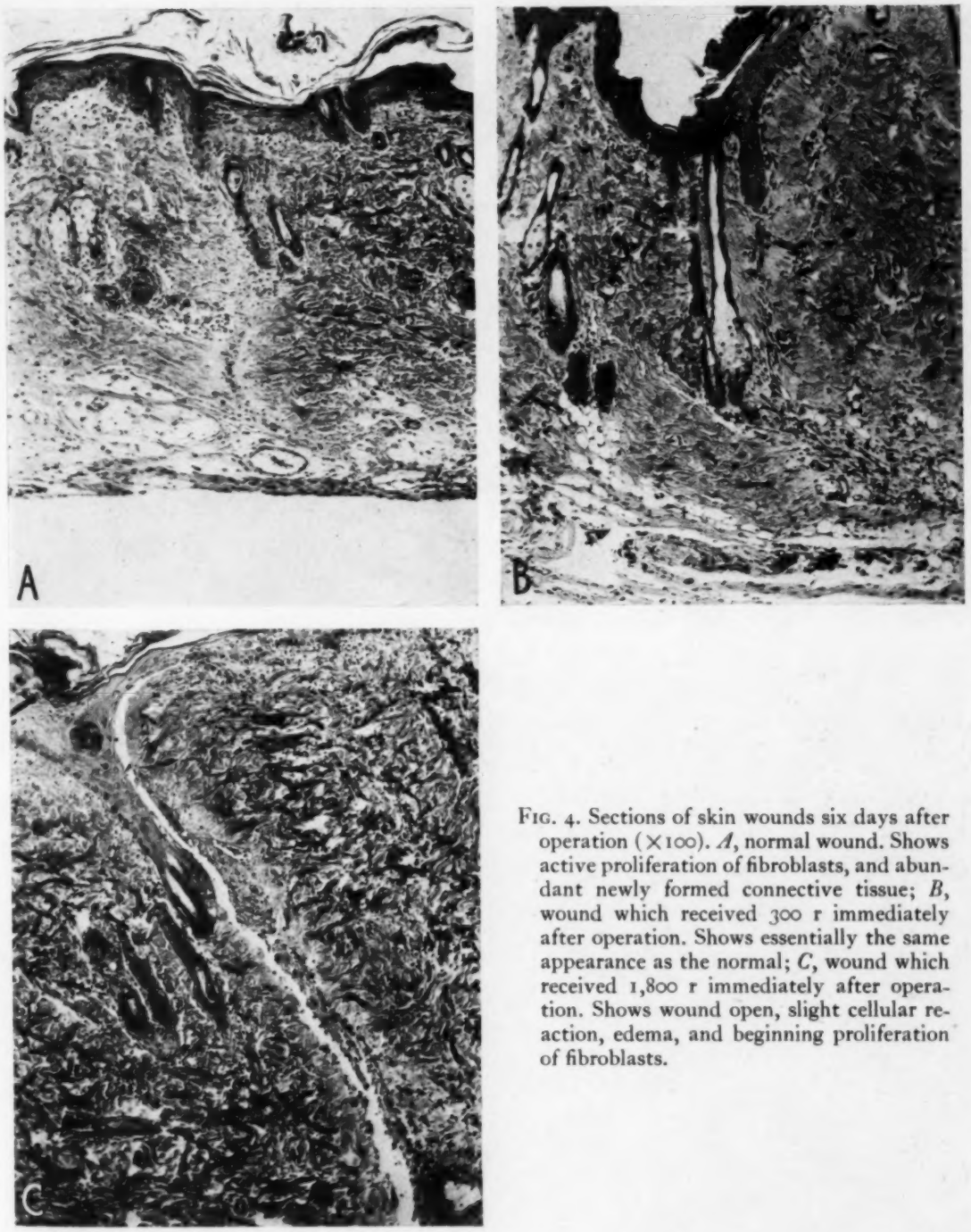

Fig. 4. Sections of skin wounds six days after operation (×100). *A*, normal wound. Shows active proliferation of fibroblasts, and abundant newly formed connective tissue; *B*, wound which received 300 r immediately after operation. Shows essentially the same appearance as the normal; *C*, wound which received 1,800 r immediately after operation. Shows wound open, slight cellular reaction, edema, and beginning proliferation of fibroblasts.

lends itself readily to accurate statistical analysis becomes apparent when the degree of individual response to irradiation is noted.

In addition to the variation in response to irradiation, there are variations in gross and especially in microscopic appearances of normal healing wounds in rats which render the usual methods of study rather unsatisfactory.

Acceleration of healing following small doses of radiation has been described by a number of investigators[1,3,4,5,10,13] using histological and gross appearances as criteria.

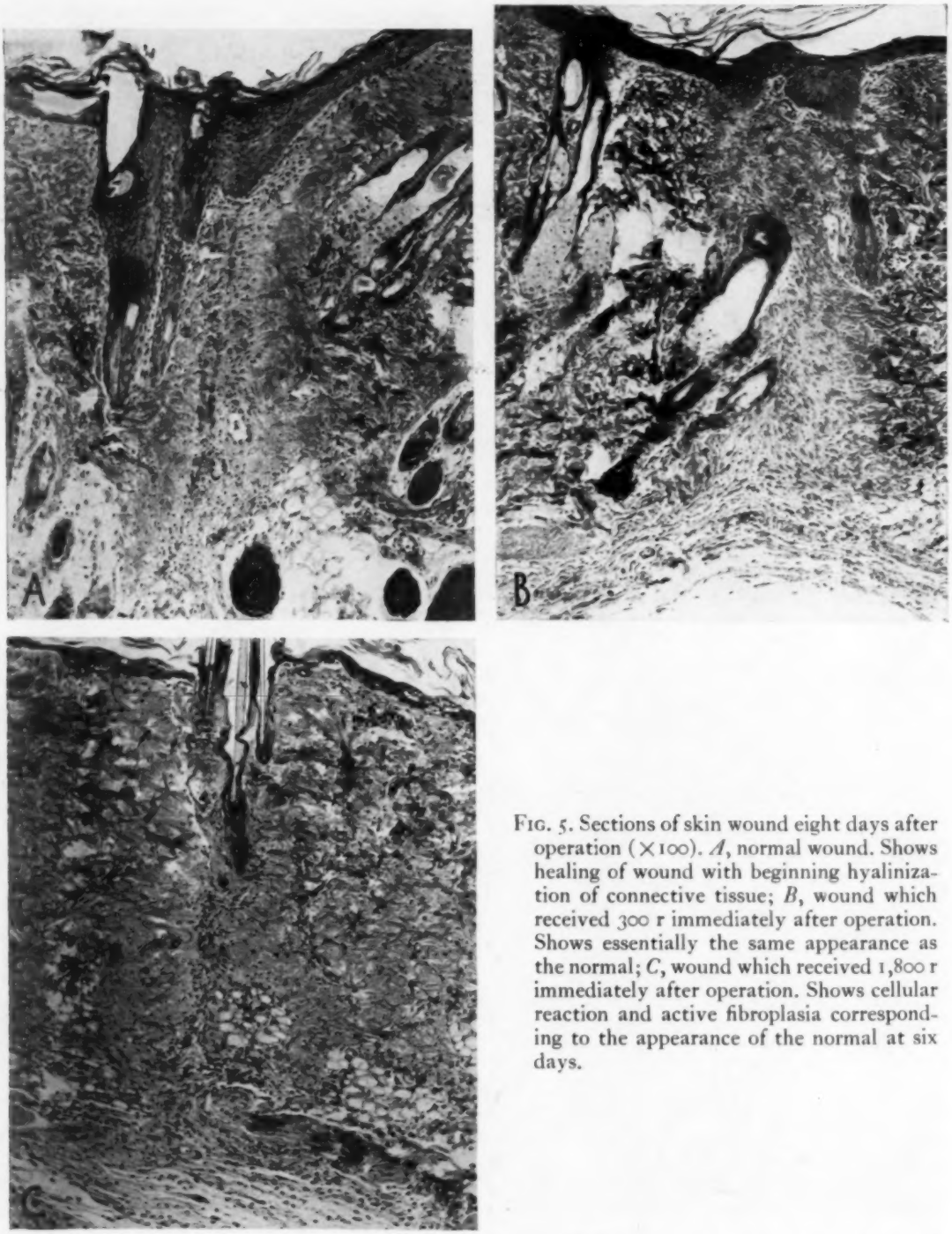

Fig. 5. Sections of skin wound eight days after operation (×100). *A*, normal wound. Shows healing of wound with beginning hyalinization of connective tissue; *B*, wound which received 300 r immediately after operation. Shows essentially the same appearance as the normal; *C*, wound which received 1,800 r immediately after operation. Shows cellular reaction and active fibroplasia corresponding to the appearance of the normal at six days.

In the present experiment, although the finding of increased tensile strength following small doses of roentgen rays was definite, the microscopic and gross appearances of wounds varied to such an extent that it would have been impossible to come to any conclusion as to the rate of healing.

It will be noted from the curve (Fig. 1*A*) that the tensile strength did not begin to b increased significantly until after ten day following operation, which is the period o active fibroplasia. It must be recognize that there may be no correlation betwee the tensile strength and fibroblastic a

tivity of a wound. Increased tensile strength does not necessarily imply stimulation of fibroplasia or other known physiological processes concerned with healing.

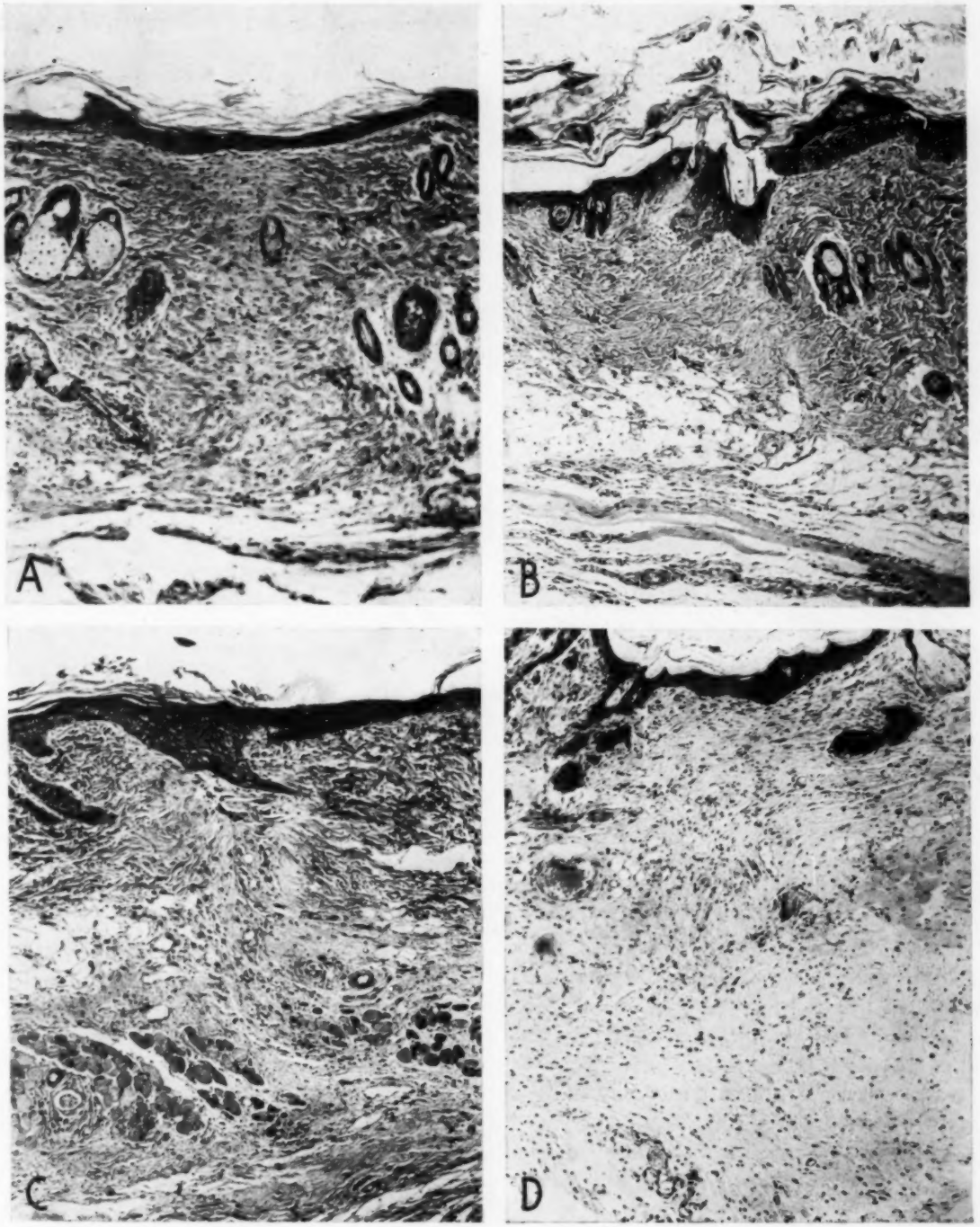

FIG. 6. Sections of skin wounds ten days after operation (×100). *A*, normal wound. Shows a well-healed scar with mature connective tissue; *B*, wound which received 1,800 r immediately after operation. Shows fibroplasia, and immature connective tissue; *C*, wound in skin which received 1,800 r one week before operation. Shows essentially the same appearance as the wound which received 1,800 r immediately after operation; *D*, wound in skin which received 1,800 r three weeks before operation. Shows a stage of healing corresponding to the two preceding sections. Note absence of normal hair follicles.

Pohle *et al.*[11,12] using roentgen rays and Nathanson[10] using radium found that large doses of radiation given to wounds immediately, twenty-four, and forty-eight hours after operation resulted in delayed healing as judged by histological and gross examination. Both investigators reported that the wounds which received irradiation twenty-four hours after operation showed the most marked interference with healing. Pohle found no effect on healing when the skin was irradiated prior to operation.

In the present work there is definitely a decrease in tensile strength of wounds following large doses of roentgen rays given immediately after operation. The histological and gross findings agree with those reported by Pohle and by Nathanson.

It is of considerable interest to find essentially the same decrease in tensile strength of wounds resulting from irradiation of the skin one and three weeks preceding operation.

Failure to demonstrate significant decrease in tensile strength of wounds to which a large dose of roentgen rays was given twenty-four hours after operation is an unexpected and unexplained finding which is at variance with the anatomical observations of Pohle and of Nathanson. It is felt that the present method of study offers a more accurate and reliable index of healing than the methods previously employed.

CONCLUSIONS

From the experimental work the following conclusions as to the effect of radiation on wound healing in rats may be drawn:

1. Skin wounds irradiated with 300 roentgens immediately after operation show significant increase in tensile strength.
2. There is no anatomical evidence of a stimulation effect on the healing of wounds irradiated with 300 roentgens.
3. 1,020 and 1,800 roentgens given immediately after and one, and three weeks before operation result in a significant decrease in tensile strength of skin wounds.
4. Irradiation of skin incisions with 1,800 roentgens twenty-four hours after operation causes no significant decrease in tensile strength of wounds.

I wish to thank Miss Cornelia Hewitt of the Department of Surgery for her assistance throughout the experimental work.

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MEASUREMENTS OF ROENTGEN-RAY PRODUCTION IN THE RANGE 0.8 TO 2.0 MILLION VOLTS

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SOME preliminary focusing tests with an electron beam have been made in the accelerating tube of the Massachusetts Institute of Technology electrostatic generator in its new location in Cambridge. In the course of these tests it has been possible to make some measurements on roentgen-ray intensity as a function of angle, absorber, and voltage in the range 0.8 to 2.0 million volts. Since the first extended application of the generator will be to the acceleration of a deuteron beam for the production of artificial radioactivity, the roentgen-ray measurements necessarily have been limited in precision and scope. The results are presented primarily because of their possible practical value to those considering the installation of high voltage roentgen-ray equipment.

EQUIPMENT

The two units of the belt electrostatic generator formerly located at Round Hill[1] have been moved to Cambridge and installed with terminals in contact to obtain in effect a single high voltage terminal supported on two insulating columns. The charging belt assembly is installed in one column and the accelerating tube[2] in the other. In this arrangement the target is located in an underground room and is electrically at ground potential. Terminal voltage is measured by means of a generating voltmeter mounted directly over the high voltage body in the surface of the smooth shell housing the generator. The generator and its accessories are completely remote controlled for the protection of the operators. A full description of this high voltage installation will be published in the near future.

The target (Fig. 1) will be described in some detail because of its bearing on the total roentgen-ray yield and on the theoretical interpretation of the results. The target consists of a double-walled copper cup with an inner lining of lead[3] to secure both effective water cooling and a high efficiency in the production of roentgen rays. Thus the total roentgen radiation emerging from the target consists of the

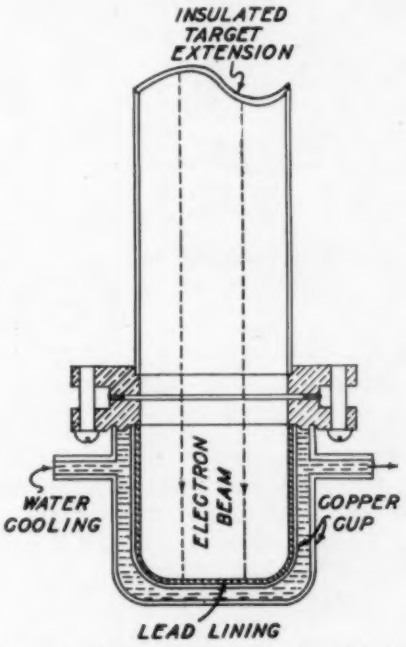

FIG. 1. Cross section of the lead-lined, water-cooled target.

general radiation appropriate to the electron energy plus some characteristic lead radiation, all filtered by approximately 1.5 mm. of lead and 3.0 mm. of copper. The target cup is bolted to a long metal tube, electrically insulated to obtain a deep Faraday cage for measuring the target current. The entire electron beam entering the metal tube is focused into the cup to insure the bombardment only of the lead surface and to avoid the escape of secondaries. Retarding potentials of both polari-

ties have shown that the contribution to the measured target current due to secondaries is negligible.

All intensity measurements were made with a Victoreen condenser type r-meter and are expressed in terms of r/minute-

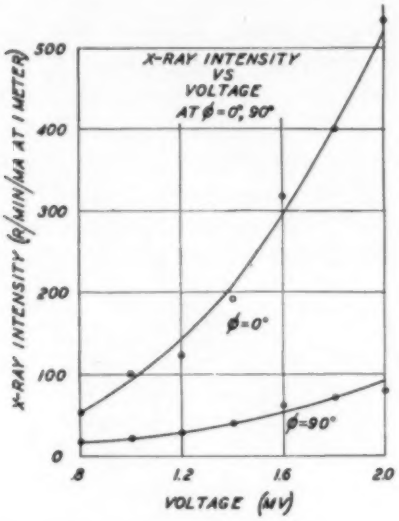

Fig. 2. The variation of roentgen-ray intensity with voltage for $\phi=0°$ and $\phi=90°$.

milliampere at 1 meter from the target. Although an "air wall" instrument does not measure the free air ionization required by the definition of the roentgen, it measures an ionization which is equal to the other to within a few per cent above 0.6 million volts.[4] Air wall chambers of various designs used by different observers have given consistent results when applied to gamma-ray measurements, whereas the standard air chamber in its present form has proved to be unsatisfactory at very short wave lengths.[5] The difference between air wall chamber measurements and various biological standards in the range 0.2 to 0.7 million volts has been shown to be small and probably not significant.[6] In view of these results, the convenience of the Victoreen r-meter and its wide use recommend it as a standard of comparison.

EXPERIMENTAL RESULTS

The variation of roentgen-ray intensity with voltage in the range 0.8 to 2.0 million volts, both in the forward direction and perpendicular to the electron beam, is shown in Figure 2. At each voltage the intensities in the two directions were measured simultaneously, using 100 r and 25 r chambers at a distance of 25 cm. from the target. For each reading the time of application of the voltage (one to two minutes) and the value of the target current (8 to 16 microamperes) were chosen to bring the deflection to the most sensitive part of the scale.

The variation of intensity with azimuthal angle between $\phi=0°$ and $\phi=90°$ at 1.0, 1.5 and 2.0 million volts is shown in Figure 3. The readings were taken with target currents between 15 and 100 microamperes, for deflection times between one-half and two minutes, and at a distance of 25 cm. from the target. The value of intensity at each angle represents the average of two readings, one taken on each side of $\phi=0°$.

Figure 4 gives the absorption of 1.0, 1.5 and 2.0 million volt roentgen rays in lead for thicknesses up to 1 inch. The readings

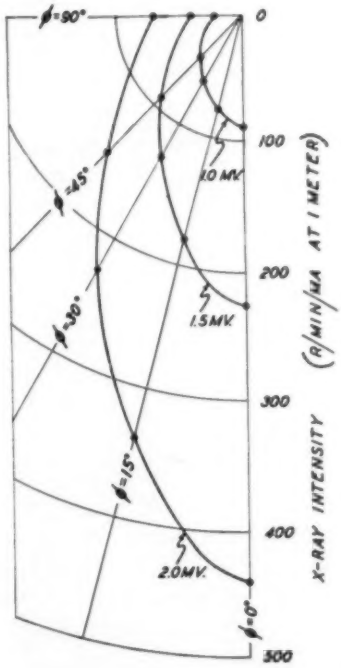

Fig. 3. The variation of roentgen-ray intensity with azimuthal angle at 1.0, 1.5 and 2.0 million volts.

were taken with target currents between 6 and 160 microamperes, for deflection times between one-half and four minutes, and at a distance of 50 cm. from the target. The geometrical arrangement of target, absorber and ionization chamber is shown in Figure 5. A separate test showed that, with no absorber, this intensity follows the inverse square law for distances between 25 and 50 cm. from the target.

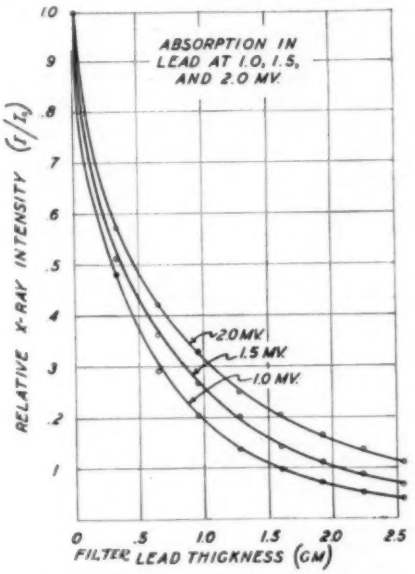

FIG. 4. Absorption of 1.0, 1.5 and 2.0 million volt roentgen rays in lead for thicknesses up to 1 inch.

DISCUSSION

In planning a high voltage roentgen-ray installation, a knowledge of the approximate intensity, angular distribution, and hardness of the radiation as a function of voltage should be useful. For this purpose, these experimental results may be of value. According to Figure 2, the intensity in the forward direction, which is of more significance than the total radiation from the target in beam therapy, increases approximately as the 5/2 power of the voltage. The well-known concentration of the roentgen radiation in the forward direction at high voltages is well illustrated both by a comparison of the two curves in Figure 2 and by the polar graph of Figure 3.

It has been shown theoretically and, up to 0.5 million volts, experimentally,[7] that in the case of a thin target or heavily filtered radiation, there is actually a dip in intensity in the line of the forward

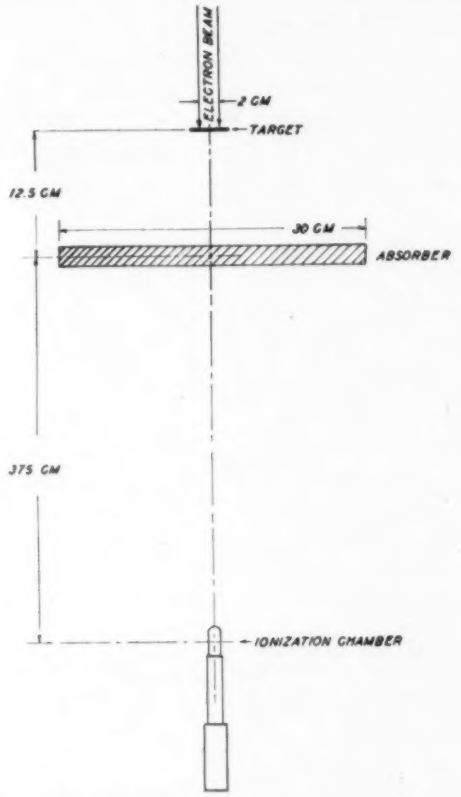

FIG. 5. The geometrical arrangement of the target, absorber and ionization chamber used to obtain the curves of Figure 4.

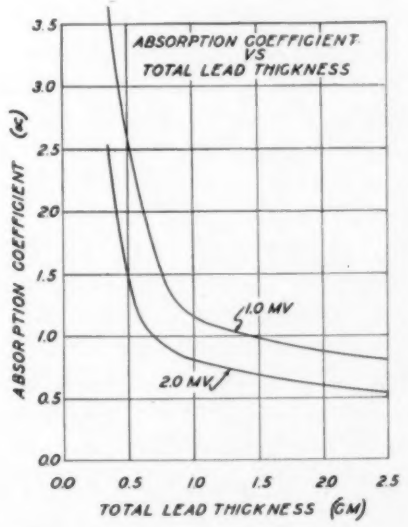

FIG. 6. Absorption coefficient as a function of total lead thickness.

direction, the maximum occurring in a cone surrounding this line. However, this cone is so narrow at the voltages used in these experiments (about 16° at 2.0 million volts), and the effect is so easily masked that no effort has been made to arrange the apparatus to show it.

The absorption measurements of Figure 4 are re-plotted in Figure 6 to give directly the absorption coefficient,

$$\alpha_x = \frac{1}{\Delta x} ln \left(1 + \frac{\Delta I}{\Delta x}\right),$$

of the radiation which has passed through a thickness, x, of lead filter. $\Delta I/\Delta x$ is the negative slope of the absorption curve at x. The effective lead thickness of the target cup has been included in Figure 6. It should be pointed out that this absorption coefficient, measured with the large effective field shown in Figure 5, will be somewhat smaller than the "total absorption coefficient," measured with a very small field.

A striking argument in favor of high voltage roentgen-ray equipment can be deduced from the foregoing results. For example, we find from the curves that at 1.0 million volts and 0.4 cm. lead filter the intensity is 70 r/min-ma. at 1 meter with $\alpha = 3.2$; whereas at 2.0 million volts and 1.0 cm. lead filter the intensity is 220 r/min-ma. at 1 meter with $\alpha = 0.80$. Under these conditions the radiation from a 2 million volt machine is three times as intense and four times as hard (defined by the ratio of the absorption coefficients) as that from a 1 million volt machine. In this connection, it will be found of interest to compare the output of a 2.0 million volt machine with the gamma-ray spectrum of radium, as has been done by Eve and Grimmett[8] for 1.0 million volt radiation.

These measurements were not taken with a view to making a test of existing theories of roentgen-ray production and are not considered to be useful for this purpose. Present theory considers only the general radiation due to first collisions of the electrons. In an ordinary thick target there will be an addition of softer components having a wider angular distribution due to successive collisions of the electrons in the thick target, and also an appreciable contribution of radiation characteristic of the target material, relatively soft and isotropic in distribution. Both of these effects broaden the observed angular distribution curves and increase the absorption coefficient at small filter thicknesses.

We wish to express our indebtedness to other members of the group which have cooperated in developing the generator and equipment with which these results were obtained, in particular to Dr. R. J. Van de Graaff, to Dr. C. M. Van Atta, and, for his assistance with the measurements as well, to Mr. J. Clark. Discussions of the theoretical implications of the results with Dr. G. G. Harvey have been of great value to us. We wish also to acknowledge the continued support of the Research Corporation.

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VOL. 41, NO. 4

"DOUBLE BEAM" ROENTGEN THERAPY*

(SIMULTANEOUS IRRADIATION THROUGH TWO PORTALS AT OPPOSITE SIDES)

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and
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THE success of giving a destructive dose of roentgen rays to a deep-seated tumor is governed by the tolerance dose of the skin. The physical properties of the roentgen rays make it impossible to deliver the destructive tumor dose through one field of entry without complete destruction of the skin. Tumors, therefore, are generally irradiated alternately through a number of different portals, or the patient is rotated in front of a narrow beam of roentgen rays with the tumor in the center of rotation.[1]

Besides the use of several portals of entry, division and protraction of the dose are other means of increasing the tolerance dose of the skin. The importance of the division of the dose is generally recognized, whereas the degree of protraction varies within wide limits. A high degree of protraction, desirable for increasing the tolerance of the skin, is very often not used for the simple reason of economy, since the duration of the irradiation becomes too extended.

In the following, a method of irradiation of deep-seated tumors is described which makes it possible to give approximately twice the tumor dose during a single treatment without increasing the skin dose. This method consists in irradiating a tumor simultaneously through two opposite portals by the use of two roentgen tubes.[2]

From a physical point of view, the same physical effect (amount of absorbed energy) would be accomplished by treating, first, through one field of entry and at another time, through another field of entry, the constants of the irradiation procedure remaining the same.

It seems difficult to conceive that there should be obtained biologically a different effect by simultaneous irradiation through two fields of entry as contrasted with irradiation at different times through the same two portals, unless one is willing to assume that the greater homogeneity of the volume dose at the site of the tumor, produced by the simultaneous irradiation through two portals, produces an increased effect upon the tumor.

Apart from these considerations, the simultaneous irradiation through two opposite portals makes possible a more complete utilization of the capacity of modern roentgen-ray machines and will cut the time of irradiation in half for a given protraction as applied to the skin.

The simultaneous irradiation through two opposite portals could be accomplished in the simplest way by the use of shock- and ray-proof equipment. For economic reasons this was not possible. Use had to be made of the available equipment, consisting of a tube in a large lead-lined box (Fig. 1) of the dimensions 211 by 134 by 101 cm., delivering a horizontal beam at a height of approximately 60 cm. A simple tube stand was built for the second tube. As the patient has to be brought between

[1] E.g., Dessauer, *Strahlentherapie*, 1938, *60*, 546.

[2] Recently Failla (*Phys. Rev.*, 1938, *53*, 916) described an experimental arrangement in which two roentgen-ray tubes placed opposite each other are operated by the appropriate half wave of a high voltage transformer.

* This study and presentation were made possible by a fund given by Mrs. Charles Wyzanski in memory of her husband.

the cones and the position of the present box could not be changed, the second tube was made movable in the direction of the axis of the beam. For this purpose, the tube carrier (carrying a water-cooled, ray-protected Coolidge tube; and permitting adjustment of the height of the tube as well as rotation around a vertical axis) is mounted on a set of rails and can be moved along the axis of the beam by means of a screw. Shields of bakelite near the high potential terminals of the tube give sufficient protection to the patient against electric shock. A high tension switch separates this tube from the high voltage circuit if treatment with one tube only is desired. The set-up is operated as follows: The tube on the movable stand is moved back, then the patient is put into the required position and the tube moved up to the skin of the patient. As focal distance, 60 cm. was chosen, the reason being that a shorter distance would not have given sufficient protection from electric shock. The tubes are operated at 190 kv. and 4 or 5 ma., giving the same intensity of 2.5 or 3.2 r/min. (air) respectively.

The curves for the depth doses of the beam resulting from simultaneous irradiation through two opposite portals can be calculated by adding the ordinates of the depth doses of the single beams. Figures 2, 3 and 4 give the depth doses, as measured for the single beam as well as for the double (opposite) beam in the central ray. The measurements of Figures 2 and 3 were made in a rice phantom with the dimensions 40.5 by 33.5 by 30.5 cm., by means of a Victoreen condenser chamber held in position by a clamp. The measurements of Figure 4 were made in a paraffin cast of the human neck.[3]

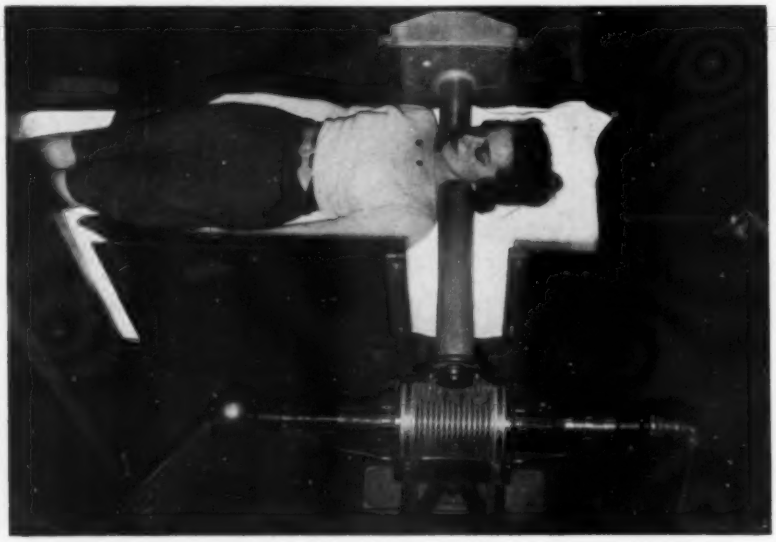

Fig. 1

As is to be expected, the curves for the opposite beams are symmetrical, giving a section in the middle in which the percentage depth dose is uniform over several centimeters.

If the tumor is situated centrally and is not too large, it will receive a more or less uniform volume dose during the time of irradiation. If the tumor is not situated centrally, it can be brought into a central position by building up with paraffin the side of the body to which the tumor is nearest, thus bringing the tumor into the section in which the volume dose is uniform.

This method of irradiation was first used in treating laryngeal cancer. The following

[3] Both rice and paraffin give too high depth doses as compared with those measured in water (e.g., Quimby and Arneson, Am. J. Roentgenol. & Rad. Therapy, 1937, *37*, 93). These curves are only given to illustrate the effect of the double beam.

irradiation factors were used: 190 kv., 4 ma., 2 mm. Cu, 1 mm. Al, effective wave length 0.016Å, intensity of each beam 2.5 r/min. (air), each field 8 cm. in diameter, focus-skin distance 60 cm.; 100 r (air) each beam was given twice daily to a total daily dose of 400 r (air). It became apparent that double beam irradiation gave less skin effect than single beam irradiation for the same total dose, while the mucous membrane reaction and the tumor reaction were increased for the double beam. The mucous membrane and tumor reaction arose at about the same time as in the cases receiving single beam irradiation. The mucous membrane reactions were obtained after the tenth or thirteenth day, and continued to complete destruction of the germinal epithelium and the formation of a false membrane. The skin effect, which was usually at its height (in single beam irradiation) at approximately the twenty-fifth day, was considerably milder and often did not bare the derma. This effect was so pronounced that the double beam was used for deep-seated cancers.

In the case of cancer of the bladder, the same irradiation factors are employed as in laryngeal cancer, except that the tube current was 5.0 ma., giving an intensity of 3.2 r/min. (air). Seven fields are used varying in size from 48 to 100 cm.^{2}: two anterior, two posterior, two lateral, and one perineal field. All fields except the perineal are subjected to double beam irradiation. The perineal field receives 3,000 r (measured in air) in fifteen days; 3,000 r (measured in air) is given to each of six fields in from forty to fifty days, giving a total dose to the skin of 21,000 r (measured in air). Due to the position of the bladder, the anterior abdominal wall had to be built up to

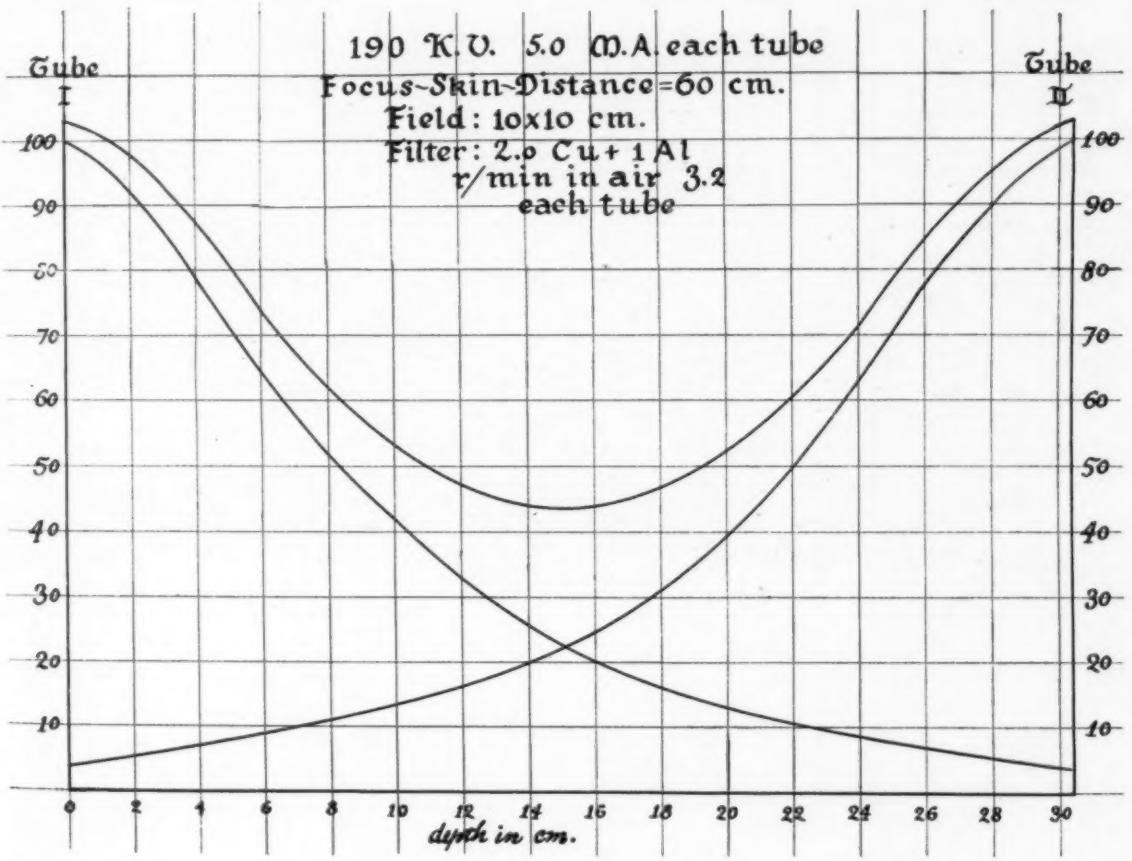

Fig. 2

assure a homogeneous distribution of the radiation in the bladder. The cases showed only moderate desquamation and tanning when using the smaller fields, and a mild epidermitis with an incomplete denudation of the derma when using the larger fields. The reaction in the bladder is marked.

The bladder mucosa, as is observed in the laryngeal mucosa following irradiation, shows a complete destruction of the germinal epithelium. The patient urinates shreds of bladder mucosa along with tumor tissue. The rectal mucosa is only slightly affected due to the high resistance of goblet cell epithelium to irradiation. The rectal symptoms are usually tenesmus and mild diarrhea which lasts only a few days and is easily relieved by paregoric. The bladder symptoms are an increased frequency with dysuria. These patients begin to show these symptoms approximately on the twenty-fifth day following irradiation. They usually last for several weeks and require mild sedation. The dose given and the reaction following are necessary to destroy most transitional cell carcinomas. For glandular carcinoma, a much higher tumor dose is necessary.

The effect of the double beam irradiation in laryngeal, ovarian, uterine, and esophageal cancer has been pronounced enough to suggest this form of roentgen therapy in all such cases. Altogether approximately 50 cases were treated. Treatment was begun three years ago. End-results are not given because of the short period of time elapsed.

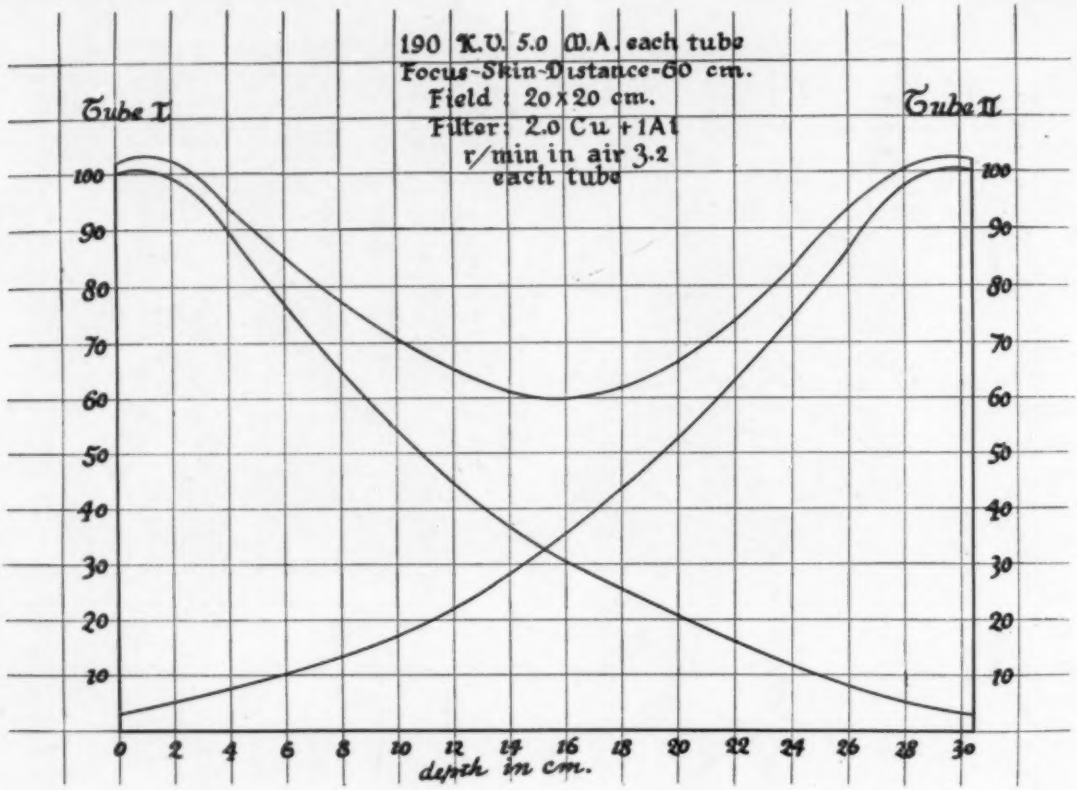

Fig. 3

Three cases selected at random from a large group treated over a period of two and a half years are described in the following:

Case 1. N. K., male, aged forty-four. His chief complaint was irritation of the the throat following deglutition. Examination of the larynx revealed a large irregular mass on the internal surface of the epiglottis which continued across the aryepiglottic fold and the

arytenoid. Biopsy showed typical epidermoid carcinoma. Double beam roentgen therapy was begun using the irradiation factors described above. Over a period of five weeks, 8,000 r (measured in air) in 40 treatments was administered simultaneously to the left and right sides of the neck. The following note was made at the examination one month after therapy: "Both vocal cords essentially normal—voice normal." Two and a half years after treatment, patient appears entirely well.

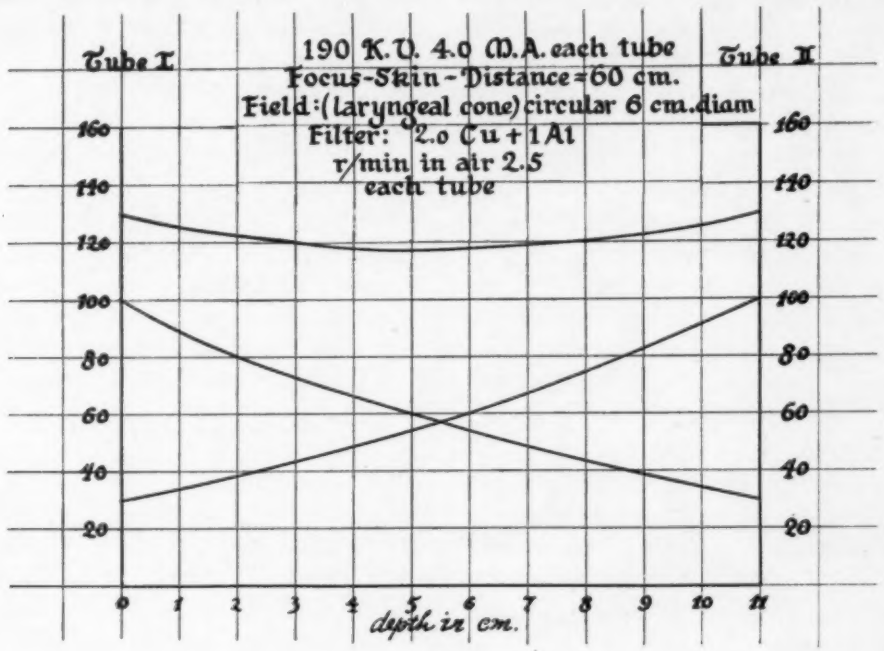

FIG. 4

CASE II. N. R., male, aged sixty-five, admitted to the hospital complaining of frequency, urgency, dysuria, nocturia, and hematuria of three months' duration. Several days after admission, suprapubic cystotomy and fulguration of the bladder tumor were performed. Pathological examination of the tumor revealed transitional cell carcinoma of the bladder. Four weeks after operation roentgen therapy was begun, using the bladder technique described above. Cystoscopic examination following treatment showed no evidence of the disease and, at the present time, one and a half years after the operation, the patient appears entirely well.

CASE III. Mrs. E. F., aged sixty-eight, was referred to the hospital because of a painful ulcerating lesion in the posterior portion of the left antrum. Roentgenographic examination showed evidence of destructive changes involving the wall of the left antrum and the orbital portion of the superior maxilla on the left. Biopsy revealed salivary gland carcinoma of the left antrum, and roentgen therapy was begun immediately using the irradiation factors identical with those of Case I. Over a period of fourteen days she received 2,200 r (measured in air) to the left and right antra simultaneously and 2,600 r additional to the left antrum alone. Several weeks later she received a second series of treatments, 1,800 r (measured in air) over a period of ten days. One month after the completion of the roentgen therapy the left antrum showed no evidence of cancer. The case is being carefully followed, and at present, almost two years since the diagnosis was established, the patient appears perfectly well.

CONCLUSION

A method is described for the simultaneous irradiation of deep-seated tumors by two roentgen-ray beams placed opposite the tumor which is at equal distance from the radiation source. This method gives an almost homogeneous distribution of the radiation in the tumor. The results obtained seem to indicate that the biological effect is more pronounced than in the case of the alternate use of a single beam.

A DENSITOMETER FOR THE MEASUREMENT OF ROENTGENOGRAPHIC SHADOWS*†

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IN THE course of investigations of the development of tuberculous lesions in the lung, it appeared desirable to make accurate comparisons of their chemical composition, histologic picture, and roentgenographic appearance with the greatest attainable precision. The study of tuberculous calcifications, in which we are chiefly interested, made it necessary to register the density of very small roentgenographic shadows, especially since we wanted to measure, not so much the total density cast by lesions of small size, as the relative density of calcium deposits within them. This required an instrument that would register accurately and reproducibly the density-difference of millimeter areas at least. The densitometers which have been described by others[1,3] were constructed for a measuring light beam of about 5 mm.—which is in excess of the total size of many shadows which we wanted to study. The difficulties encountered in constructing the apparatus which we describe in this paper were largely due to the necessity of operating with a much smaller light beam.

The chief problems which had to be met in the construction of the instrument were to provide:

1. A light source strong enough to give ample deflections on a galvanometer when passing through a millimeter area of a film of any density.
2. A stage to hold the film firmly and to carry it in any of four directions, millimeter by millimeter, and to record the position automatically.
3. A photocell in direct contact with the film to eliminate the error due to loss of light after passing through the film.
4. A system of balanced photocells to read differences in density as well as absolute density. This is necessary because the absolute density of films varies with the length of exposure and the time and temperature of development. A balanced circuit is preferred since variations in light source are difficult to overcome even with batteries, and a 3 per cent change in voltage in a tungsten filament lamp may produce a 10–15 per cent change in total light emission.[2]

DESCRIPTION*

The instrument (Figs. 1 and 2) is encased in a box of hardwood 1¼ inches thick and painted black to eliminate and absorb stray light. The box rests on a sponge rubber cushion (30). It houses the light source and cooling system, the balanced photocell B (22), the resistance for the galvanometer (29), and a set of four tubular scanning lamps (8) for general examination of the whole film. The box also acts as a base for the glass carriage plate (1) which is large enough to hold an average film. Metric steel rules (2) are screwed to the glass plate on two sides and are used for correlation of the position of that portion of the film to be examined. The film is held in place by two steel strips (3) that clamp over the film and plate.

The glass carriage is moved right and left by a metric screw (4), every revolution of which is 1 mm. The position is read on a veeder counter (5) to the tenth of a millimeter. The carriage is moved forward and

* The figures in parentheses refer to the drawings in Figure 1 as well as to the photographs in Figure 2.

* From the Department of Medicine of the University of Chicago.
† We gratefully acknowledge the indispensable technical advice and help given us by Daniel Stevens, Ph.D., and Albert E. Shaw, Ph.D., of the Department of Physics of the University of Chicago.

back by another metric screw (6) with recordings on a second veeder counter (7). The readings of both counters correlate exactly to the position of the millimeter opening in the photocell A (23) above the plate and also to the metric scales (2) at the sides of the glass plate. When any portion of a film is to be read, it is squared to the metric scale on the carriage and the

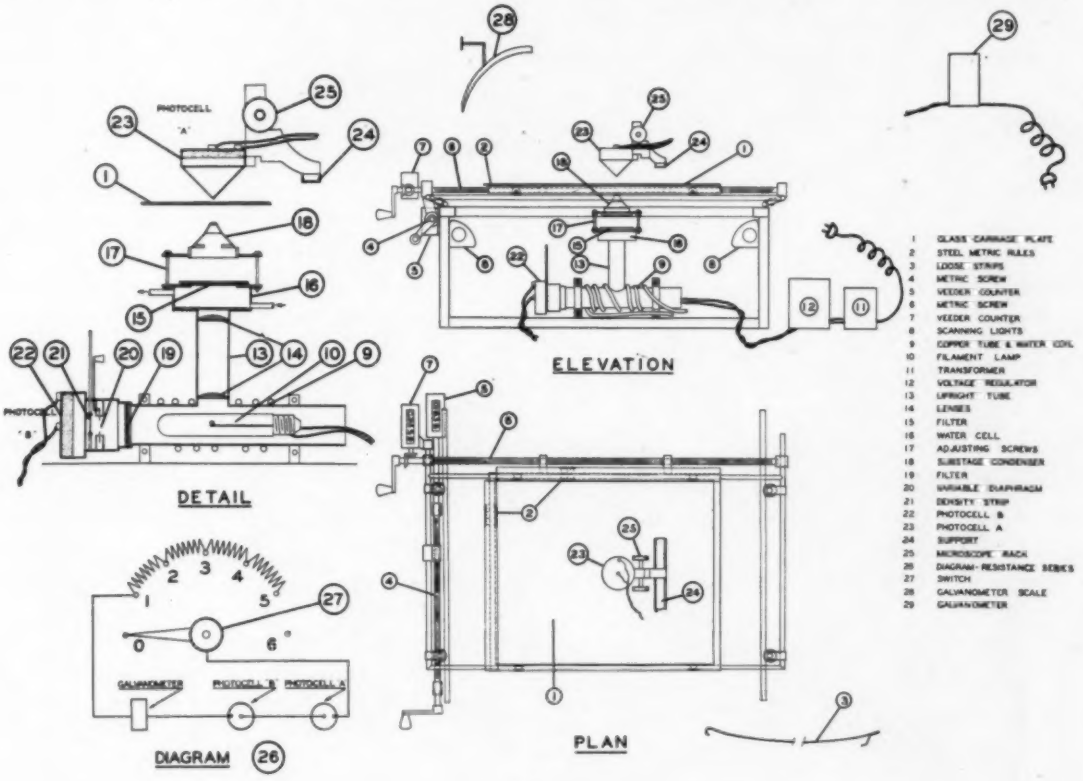


FIG. 1

(9) with the connecting wires soldered in place to prevent leakage of current. A coil (9) carrying running water encircles the copper tube to prevent overheating. A copper tube arm 10 cm. long and 3 cm. in diameter extends directly above the ribbon filament of the lamp (13). This tube contains one lens at the base and another at the top to condense the light (14). Since carriage is moved so that the counters give the same figures. The desired area is then under the millimeter opening of the photocell A.

The source of light for the photocells is a Westinghouse ribbon filament lamp, 2 T 10 S.R. 6 A, 18 amp., 6 volt, 108 watt (10), the current for which is supplied by a 6-volt, 18-amp., 150-watt Westinghouse transformer (11). The voltage output of the transformer is stabilized by a Raytheon voltage regulator (12) of 120-watt capacity, type V R-3.

The lamp is encased in a copper tube the resulting beam of light gives off considerable heat, a water cell is necessary (16). The lower surface of the water cell is a light blue-green Corning glass 3 mm. thick (No. 428)—a heat-resisting filter (15). The entire water cell is 2 cm. thick and 6 cm. in diameter. The cooled beam of light is recondensed into a ribbon of light 7 mm. long and 3 mm. wide by a substage condenser (18) held to the water cell with adjusting screws (17). The beam of light is focused directly on the upper side of the glass carrying stage (1). The millimeter opening of the photocell A (23) is

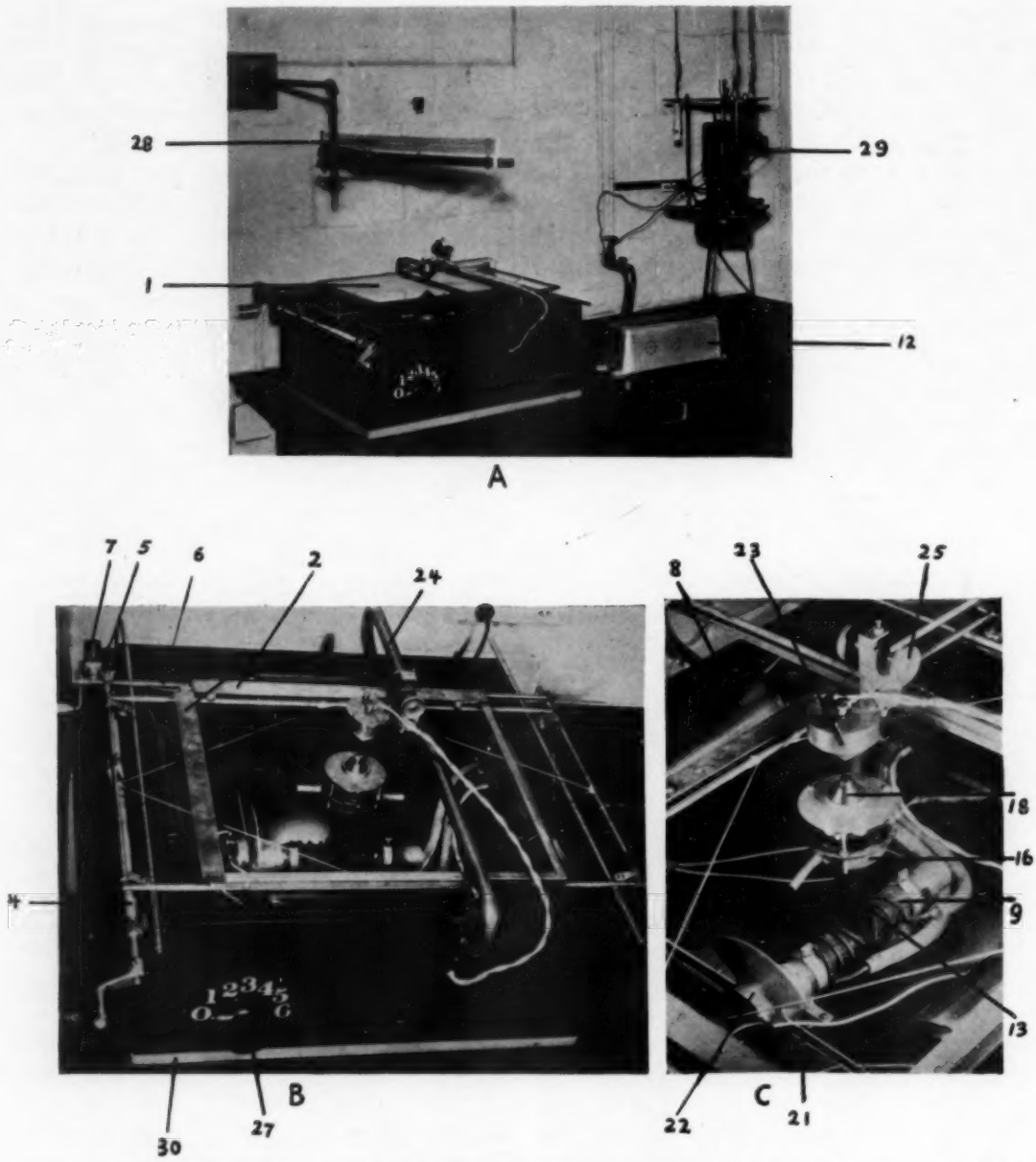
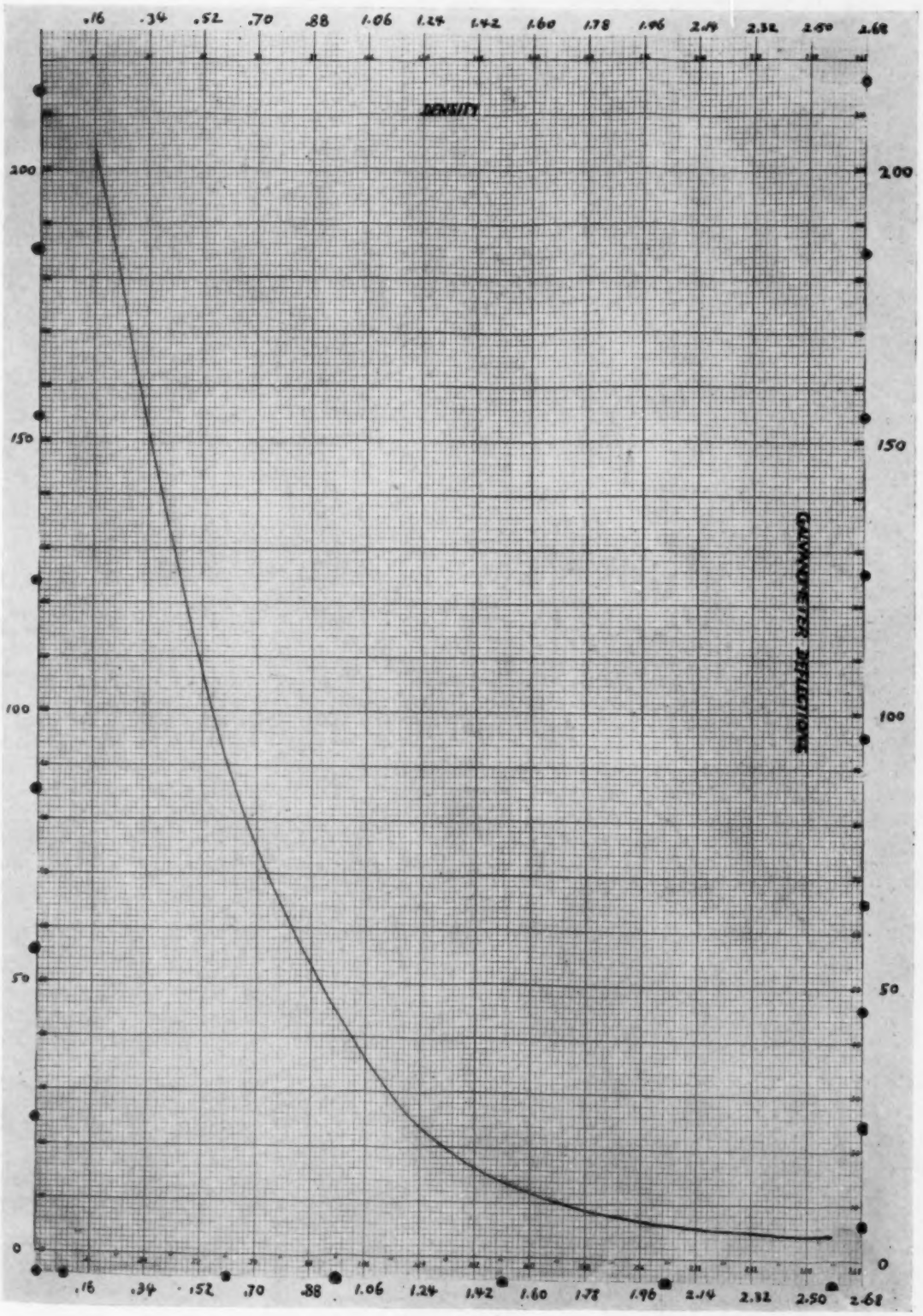


Fig. 2. *A*, total view of apparatus; *B*, top view of box; *C*, close-up of photocell arrangement.

brought down on the film directly in the center of this light.

The light for the balanced photocell B (22) is taken off the end of the main tube holding the lamp. A copper extension holds a dark blue-green filter (19) of Corning glass, 5 cm. in diameter and 5 mm. thick. The light intensity is varied by a diaphragm (20) with openings from 1 to 18 mm. The photocell B is connected directly to this diaphragm by an aluminum front holding a sliding case for a density strip (21). Thus the light entering the photocell B may be varied both by the diaphragm and the density strip to equal the light penetrating the photocell A.

The photocells are encased in copper cases. The connections are soldered and shellacked. Photocell A, which is used for reading the films, has a copper cone front with a millimeter opening for the entrance of light from the film. The photocell is


.16 .34 .52 .70 .88 1.06 1.24 1.42 1.60 1.78 1.96 2.14 2.32 2.50 2.68
DENSITY
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150
100
50
0
GALVANOMETER DEFLECTIONS

FIG. 3

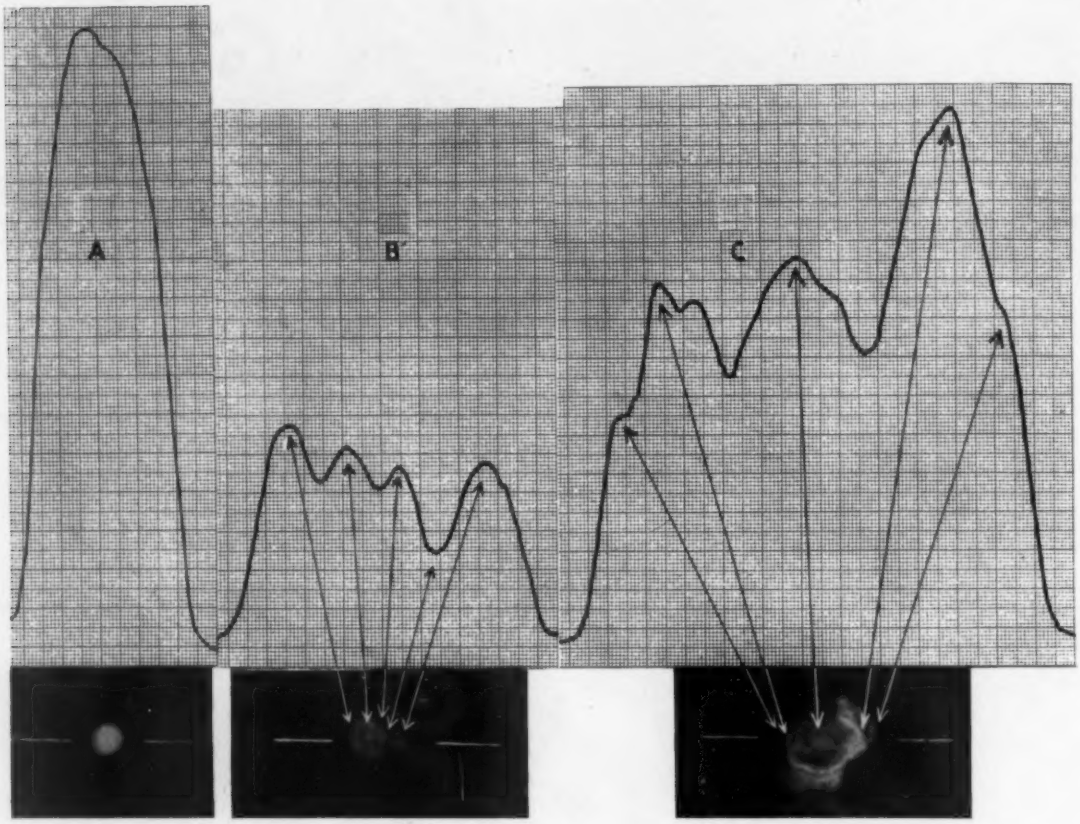

Fig. 4. The white marks on both sides of each lesion represent the ends of the lines along which the readings were made. The double-headed arrows point to some of the measured areas and their registration in the curves, respectively. For better correlation the pictures of three small tuberculous foci were enlarged to twice or more the size in the original film from which the readings were taken. The original sizes were: *A*, 11 mm.—enlarged here to 22 mm.; *B*, 7 mm.—enlarged to 17 mm.; *C*, 4 mm.—enlarged to 9 mm. *A* appears uniform to the eye, but the densitometer shows that the density decreases to a light peak in the center. *B* shows the variations in density of a nodule 7 mm. in diameter. *C* shows concentric circles of density in a larger nodule.

held rigidly in position above the glass carriage by a steel arc over the box (24) and is raised and lowered onto the film by a microscope rack and pinion (25).

The two photocells are connected so that the current flowing from them to the galvanometer (29) is the result of the difference in the amount of light striking the two cells. Inserted between photocell A and the galvanometer is a resistance series (26) to protect the galvanometer from too great a current change and to give a wider range of readings.

The resistances are wound with three-ohms-per-foot resistance wire. There are six positions on the selector switch (27) which have the absolute values of:

0	off
1	no resistance
2	28.20 ohms
3	55.79 ohms
4	112.80 ohms
5	224.62 ohms

The added resistance of the connecting wires and photocells makes it impossible to calculate the shunting factors of the five positions from the ratio of the resistances which are used to shunt the galvanometer. Consequently, the values of

the shunting factors were calculated by allowing sufficient light to illuminate the photocells so that full scale deflection (100 cm.) of the galvanometer is obtained at selector switch position 1 (no resistance). Turning the selector switch to other positions without changing the illumination on the photocells would give smaller readings depending upon the amount the galvanometer was shunted. The actual shunting factor (X) for each position (n) of the selector switch was calculated from the following ratio:

$$X_n = \frac{\text{Galv. reading at position 1}}{\text{Galv. reading at position n}}.$$

An average of ten readings was taken as the final value for each of the following shunting factors:

X_1 1	X_4 1.4
X_2 1.076	X_5 2.475
X_3 1.1597	

The galvanometric deflection at position 1 is the reading at any position multiplied by the correct shunting factor.

To standardize the readings and to obtain absolute density values, a density scale was obtained from the Eastman Kodak Research Laboratories. It contained forty-six steps calibrated in millimeter-width areas from density 0.16 to 2.79. The machine did not show any change between 2.79 and 2.58 so that area was eliminated.

With the galvanometer resting at the zero-point, 4.2, the two photocells were balanced at density 2.58. This was done by bringing density 2.58 under photocell A and varying the diaphragm and density strip of photocell B until the galvanometer read 4.2 on all the resistances. The difference in density between 2.58 and any other density was then determined by keeping photocell B at this adjustment and moving the next area of the density strip under photocell A. During any changes the galvanometer must be switched off by turning the selector switch to zero. When the unknown density is placed under photocell A, the selector switch is turned to position 1 and the reading is taken. In this manner the difference in the light penetrating density 2.58 and each of the other densities on the strip is shown by the galvanometric deflection. If at any time the deflections are carried off the scale, a higher resistance is necessary.

By plotting the density values as abscissas and the galvanometric deflections as ordinates, a geometric curve is obtained (Fig. 3). From this curve the absolute density may be interpolated for any given galvanometer deflections provided the galvanometer zero-point is set at 4.2 and the balanced photocell B at density 2.58. The curve presented here is that obtained from the density strip of the Eastman Research Laboratories.

Several exposures of the same areas, though varying in absolute density, will show identical differences in density. These differences, when read by galvanometric deflections and plotted against location, will give an accurate and reproducible picture of the contours of the area in question.

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3. Weyl, C., and Warren, S. R., Jr. Comparative photometric densitometer for measurement of x-ray film densities. *Radiology*, 1931, *17*, 946.

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

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Twenty-fourth Annual Meeting: Hotel Jefferson, St. Louis, Mo., May 15-16, 1939.

EDITORIALS

THE RELATION OF THE LYMPHATIC VESSELS TO THE SPREAD OF CANCER

SINCE the time that Asellius in 1627 first saw the widespread distribution of the lacteal vessels in the mesentery of a "well nourished dog," there has been a slow but certain accumulation of anatomical and histological data concerning the anatomical as well as the functional significance of the lymphatic system. In May, 1938, Drinker[1] of the Harvard School of Public Health reviewed our knowledge of the functional significance of the lymphatic system. One of the principal functions of this system is defense against inflammatory processes, but this is not all the story. A great deal has been learned about the lymphatic function under normal conditions. The lymphatics are a simple subsidiary circulatory mechanism and are steadily engaged in moving fluid which leaves the blood capillaries back again to the blood, and it has been estimated that fluid equal to fifty times the total blood plasma may leave the capillaries and pass through the lymphatic system in twenty-four hours. Drinker called attention to the fact that in mammals it appears that such blood proteins as leave the capillaries to enter the tissue fluids are removed by the lymphatics, that under normal circumstances this function is called into play by such factors as changes in position, movement and tissue pressure, and that the composition of lymph is due to the filtration of products from the blood and not, as has been suggested, to the universal production of this fluid in the tissues. He further says there is no evidence in favor of selective phagocytic action on the part of the lymphatic endothelium.

[1] Drinker, C. K. The functional significance of the lymphtic system. *Bull. New York Acad. Med.*, May, 1938, *14*, 231–251.

In 1932 Drinker and his associates began a series of experiments having to do with the ablation of lymphatic function in the hind leg of a dog. Repeated, centrally directed injections of a suspension of finely divided crystalline silica in 2.5 per cent quinine hydrochloride were used. In this mixture the quinine caused a painless necrosis of the tissues and the silica induced progressive fibrosis just as it does when inhaled into the lungs. As a result of repeated injections edema appeared followed by fibrosis, with increase in the growth of the leg, bringing about typically elephantiatic changes and finally epithelial proliferation in the footpads. One very striking observation was made, namely that in addition to these very definite changes of lymphadema and fibrosis, the regions where the lymph block occurred developed a surprising susceptibility to streptococcic as well as other infections.

From his studies, Drinker was led to believe that in mammals the lymphatic system retains its primitive position as part of the circulatory apparatus, but, because the permeability of the peripheral blood capillaries to protein is not quantitatively great, this function is overlooked until lymph drainage becomes an important matter, as it does when infection is spreading or when the lymphatic system is blocked and edema, elephantiasis, and hypersusceptibility to infection are inevitable.

That the lymph glands are effective filters is easy to show, and it is doubtful whether or not any extravascular protein can get back to the blood vessels without going through a lymph node. Lymph flowing into a node from a number of afferent

vessels reaches the marginal sinus and finds itself in a relatively large, umbrella-shaped lake where rate of flow becomes exceedingly low and every opportunity for settling occurs. Should the lymph node become infected then the node may steadily feed organisms into the slow lymph stream, and from being a filter, the node becomes an unassailable cesspool draining eventually into the blood which in its turn may be reasonably capable of dealing with the organisms which enter it. Another function of the nodes is to pour lymphocytes into the lymph stream and this activity may be augmented by massage of the node.

It has been known for a long time that cancer tends to spread to lymph glands adjacent to the primary neoplasm, but there has been and still remains a considerable amount of uncertainty as to the exact mode by which cancer cells reach the adjacent lymph nodes. The lack of knowledge of this mode of spread has been due to the difficulty of demonstrating the lymphatic vessels. Quite recently, Gray[2] called attention to a method of investigation which he has been carrying on in the Department of Anatomy at the University College, London. He felt that some light upon the elucidation of the problem of the spread of cancer through the lymphatic system might be gained through injecting the lymphatics, and it occurred to him and his coworkers that thorotrast might be a medium which would offer considerable aid. The ease with which the injections could be made and the facility with which the thorotrast might be followed not only in histological sections but by roentgenographic methods after the injection offered an unusual opportunity for a study of this somewhat complicated problem of the spread of cancer.

After the injections with thorotrast, roentgenograms of the specimens were made and in addition histopathological studies were made. He concluded from this combined study that the mode of spread of cancer to lymph glands is generally by means of lymphatic emboli of cancer cells carried along in the lymph stream. Secondly, the results of his studies indicate that cancer of its own accord does not generally stimulate new formation of lymphatic vessels except in cases where there is substantial formation of stroma belonging to the cancer or associated precancerous changes involving the laying down of new connective tissue in relation to epithelium, or where lymph glands are interfered with either by the presence within them of cancer deposits or by the abnormal state brought about in some unknown manner by the presence of a cancer peripherally. The formation of lymphatics in this case occurs chiefly in the region of the focal lymph glands, and it is also associated with the formation of new lymph glands by the subsequent changes occurring around the newly formed plexuses of lymphatic capillaries. Gray, however, emphasizes the fact that further work is necessary to provide proof of these phenomena but the evidence which he has obtained thus far points to its being correct.

From Gray's studies he would not imply that there is any evidence for a lymphotropic theory of cancer. He believes that the ordinary effects of cancer in appreciable masses upon the local lymphatic vessels are not lymphotropic but purely indifferent mechanical effects, leading ultimately to compression and disappearance of the lymphatic vessels within the interior of a cancer. Lymphatic thrombosis, he believes, plays very little part in these phenomena, and that cancer cells generally do not remain for any length of time within the lumen of lymphatic vessels; that is, the spread of cancer cells by their growth as cords in the lumina of lymphatics is an unusual phenomenon in cases of operable cancer, and the claim that destruction of permeated lymphatics and their contained cancer cells by thrombotic changes does occur could not be confirmed. On the grounds of anatomy and physiology, the

[2] Gray, J. H. The relation of lymphatic vessels to the spread of cancer. *Brit. J. Surg.*, Jan., 1939, *26*, 462–495.

focal lymph glands will be the first and most likely seat of glandular cancer metastasis, but subsidiary or collateral glands may also be involved, though it is to be expected that this will follow later than involvement of the ordinary focal lymph glands.

Gray, by this method of injecting lymphatic vessels with thorotrast and other work adequate for a solution of the lymphatic spread of cancer, believes he has demonstrated that for operable cases of cancer embolism is the only important method of spread and that lymphotropic theories of cancer are incorrect as are lymph-stases theories of the origin of cancer. By this ingenious method of study of a most important subject, Gray has opened up a very wide field of investigation which might profitably be pursued in the elucidation of a problem so important as the spread of cancer.

CLYDE COLUMBUS PHILLIPS
1891–1939

CLYDE C. PHILLIPS of Charlotte, North Carolina, was accidentally killed on February 11, 1939, at his home when a shotgun he was cleaning discharged. Dr. Phillips, son of the late J. L. Phillips and Adelia Masten Phillips, was born in Winston-Salem, North Carolina, on May 25, 1891, where he spent his boyhood and youth. He received his earlier education in the well-known Salem Boys' School, a parochial school of the Moravian Church in Winston-Salem, from which he graduated, and he received his medical degree from the North Carolina Medical College.

He began the practice of medicine as a country doctor in the little village of

Farmington, N. C., and later moved to Wallburg, N. C., where he continued general practice as the community doctor. On September 30, 1913, he married Miss Nell Griffith of Clemmons, N. C.

In 1918 Dr. Phillips moved to Charlotte where he became associated with Dr. Robert H. Lafferty in the practice of radiology. He applied himself to work and study in this chosen field with great success. He was a member of the American Roentgen Ray Society, the Radiological Society of North America, the Tri-State Medical Society, the North Carolina Medical Society and the Mecklenburg Medical Society. In his professional specialty he was recognized as a leader, having written many articles for publication in medical journals and for presentation before medical societies and clinics.

Dr. Phillips was an active member of the Moravian Church in Charlotte. He served as teacher of the Men's Bible Class, was president of the Men's Club and also served on the official board of the church. He was one of the promoters of the community Easter sunrise service and had served as chairman of arrangements for the Moravian Easter Band since its beginning in 1926. He also organized and led the first Boy Scout troop in Myers Park.

Dr. Phillips was respected, loved and admired by all who knew him as a man of fine judgment and as a Christian of quiet but deep consecration. In addition to his wife, he is survived by one sister, Mrs. John Reich of Winston-Salem and his foster daughter, Mrs. Reuben Russell of Charlotte. To them is extended the affectionate sympathy of a host of friends in church, community and throughout the nation.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. C. B. Peirce, Royal Victoria Hospital, Montreal, Canada. Annual Meeting: Chicago, Ill., Sept. 19–22, 1939.

American College of Radiology
Secretary, Dr. E. P. Pendergrass, University Hospital, Philadelphia, Pa. Next Meeting: Jefferson Hotel, St. Louis, Mo., May 17, 1939.

Section on Radiology, American Medical Association
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: St. Louis, Mo., May 15–19, 1939.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Atlanta-Biltmore Hotel, Atlanta, Ga., Dec. 11–15, 1939.

Radiological Section, Baltimore City Medical Society
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

Radiological Section, Connecticut Medical Society
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets twice annually in May and September.

Section on Radiology, Illinois State Medical Society
Secretary, Dr. W. W. Furey, 6844 Oglesby Ave., Chicago. Meets Rockford, Ill., May 2–4, 1939.

Radiological Section, Los Angeles Co. Med. Soc.
Secretary, Dr. Wilbur Bailey, 2007 Wilshire Blvd., Los Angeles, Calif. Meets on second Wednesday of each month at County Society Building.

Radiological Section, Southern Medical Association
Secretary, Dr. Roy G. Giles, Temple, Texas.

Brooklyn Roentgen Ray Society
Secretary, Dr. E. Mendelson, 120 E. 19th St., Brooklyn, N. Y. Meets monthly on first Tuesday, October to April.

Buffalo Radiological Society
Secretary-Treasurer, Dr. Joseph S. Gian-Franceschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months, place of meeting selected by the host.

Chicago Roentgen Society
Secretary, Dr. R. G. Willy, 1138 N. Leavitt. Meets second Thursday of each month October to May inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, Dr. Harry Hauser, 3395 Scranton Rd. Meets at 6:30 P.M. at Mid-Day Club rooms on fourth Monday each month, October to April, inclusive.

Denver Radiological Club
Secretary, Dr. E. A. Schmidt, 4200 E. 9th Ave., Denver, Colo. Meets third Tuesday of each month.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

Florida State Radiological Society
Secretary, Dr. J. H. Lucinian, 403 Huntington Bldg., Miami. Meetings in May and November.

Georgia Radiological Society
Secretary, Dr. R. C. Pendergrass, Prather Clinic Bldg., Americus, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

Illinois Radiological Society
Secretary, Dr. E. P. Halley, Decatur and Macon County Hospital, Decatur, Ill. Meetings held quarterly, time and place designated by president.

Indiana Roentgen Society
Secretary, Dr. C. C. Taylor, 23 E. Ohio St., Indianapolis, Ind. Meeting held the second Sunday in May annually.

Long Island Radiological Society
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

Michigan Association of Roentgenologists
Secretary, Dr. C. S. Davenport, St. Lawrence Hospital, Lansing. Three meetings a year, Fall, Winter, Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. I. I. Cowan, Mt. Sinai Hospital, Milwaukee, Wis. Meets monthly on first Friday at University Club.

Minnesota Radiological Society
Secretary, Dr. H. M. Weber, Mayo Clinic, Rochester, Minn.

Nebraska Radiological Society
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets first Wednesday of each month, at 6 P.M., at either Omaha or Lincoln.

New England Roentgen Ray Society
Secretary, Dr. A. O. Hampton, Massachusetts General Hospital, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

Radiological Society of New Jersey
Secretary, Dr. W. J. Marquis, 198 Clinton Ave, Newark. Meets annually at time and place of State Medical Society. Mid-year meetings at place designated by president.

New York Roentgen Society
Secretary, Dr. R. D. Duckworth, 170 Maple Ave., White Plains, N. Y. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

Central New York Roentgen Ray Society
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year—January, May, November.

Pacific Roentgen Club
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport, Pa. Annual meeting, June 2 and 3, 1939. Bedford Springs Hotel, Bedford, Pa.

Philadelphia Roentgen Ray Society
Secretary, Dr. B. R. Young, Temple University Hospital. Meeting first Thursday of each month from October to May inclusive, at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

Pittsburgh Roentgen Society
Secretary, Dr. H. W. Jacox, 4800 Friendship Ave., Meetings held second Wednesday each month, 4:30 P.M., October to June at various hospitals.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. S. C. Davidson, 277 Alexander St., Meets on second Thursday from October to May, inclusive, 8 P.M., Rochester Academy of Medicine Building.

St. Louis Society of Radiologists
Secretary, Dr. W. K. Mueller, University Club Bldg. Meets fourth Wednesday of October, January, March and May, at a place designated by the president.

San Francisco Radiological Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco. Meets monthly on first Monday at 7:45 P.M., alternately at Toland Hall and Lane Hall.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

South Carolina X-Ray Society
Secretary, Dr. Hillyer Rudisill, Jr., Roper Hospital, Charleston. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. F. B. Bogart, 311 Medical Arts Bldg. Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. H. C. Harrell, 517 Pine St., Texarkana, Texas. Next regular meeting in Temple, Texas, 1939.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

Virginia Radiological Society
Secretary, Dr. V. W. Archer, University Hospital, University, Va. Meets annually in October.

Cuba

Sociedad Cubana de Radiologia y Fisioterapia
Secretary, Dr. Francisco Padron, Enrique, Villuendas 64, Havana, Cuba. Meets monthly in Havana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets monthly on third Thursday, from November to June inclusive, at 8:15 P.M., 32 Welbeck St., London.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine, 1, Wimpole St., London, W. 1.

Faculty of Radiologists
Secretary, Dr. Barbara M. Key, 32 Welbeck St., London, W.1, England.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to Nov. incl. for scientific discussion.

Canadian Association of Radiologists
Secretary, Dr. A. C. Singleton, Medical Arts Bldg., Toronto, 5, Ontario.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext., Halifax, N.S.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

Continental Europe

Belgian Society of Roentgenology
Secretary, Dr. J. Boine, Avenue des Alliés, 134, Louvain (Belgium).
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7, Madrid, Spain. Meets monthly in Madrid.

Société de Radiologie Médicale de France
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean, La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel. Meets annually in different cities.

Société Francaise d'Electrothérapie et de Radiologie Médicale
Meets monthly on fourth Tuesday, except during month of August and September, 12 Rue de Seine, Paris.

Association of German Roentgenologists and Radiologists in Czecho-Slovakia
Secretary, Dr. Walter Altschul, German University, Prague, 11.52.

Deutsche Röntgen-Gesellschaft (Gesellschaft für Röntgenkunde und Strahlenforschung)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
Permanent Secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

Süd- und Westdeutsche Röntgensellschaft
Meets annually in different cities.

Nord- und Ostdeutsche Röntgengesellschaft
Meets annually in different cities.

Dutch Society of Electrology and Roentgenology
Holds two meetings a year in Amsterdam, one in the Spring, and one in the fall.

Societa Italiana Radiologia Medica
Secretary, M. Ponzio, University of Turin, Prof. Turin

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania.
Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly on first Monday at 8 o'clock.

Polish Society of Radiology
Secretary, Dr. Jan Kochanowski, 45 Gornoslazka St., Warsaw. Meets annually.

Warsaw Section, Polish Society of Radiology
Secretary, Dr. B. Krynski, 11 Zielna St.
Meets once a month except in the summertime.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summertime:

Society of Medical Radiology in Sweden
Meets in Stockholm.

Society of Medical Radiology in Norway
Meets in Oslo.

Society of Medical Radiology in Denmark
Secretary, Dr. G. Biering, Copenhagen.
Meets the second Wednesday of each month from October to July in Copenhagen, at 8 o'clock in the State Institute of Roentgenology.

Society of Medical Radiology in Finland
Meets in Helsingfors.

Vienna Roentgen Society
Meets first Wednesday of each month, at 6:30 P.M. at Zentral-Röntgen Institut des allgemeinen Krankenhauses Alserstrasse 4.

Orient

Japan X-Ray Association
c/o Orthopedic Surgery, Tokyo Imperial University. Meets annually in April.

Kinki Roentgen-Abend Society
Director, Dr. Prof. Taiga Saito, Ogawaoike Tyoto Japan. Meets bi-monthly on third Sunday.

AMERICAN RADIUM SOCIETY

As announced in the March issue of the JOURNAL, the Twenty-fourth Annual Meeting of the American Radium Society will be held at the Jefferson Hotel, St. Louis, Missouri, on Monday and Tuesday, May 15 and 16, 1939. The following is the preliminary scientific program which has been arranged for the meeting:

1. Presidential Address. William P. Healy, M. D., New York City

2. Effect of Irradiation on Normal and Metastatic Lymph Glands. Fred J. Taussig, M. D., St. Louis

3. Keratoses and Carcinoma Following Irradiation. James J. Duffy, M. D., New York City

4. Carcinoma of the Anus, Orville N. Meland, M. D., Los Angeles

5. Surface Application of Radon in Rectal Cancer. George E. Binkley, M. D., New York City

6. Carcinoma of the Large Bowel. William M. Shedden, M. D., Boston, and Richard Dresser, M. D., Boston (by invitation)

7. Further Studies of the Rôle Played by Certain Normally Occurring Intracellular Chemical Compounds in Growth and Development. Stanley P. Reimann, M. D., Philadelphia (by invitation)

8. A New Instrument for the Intralaryngeal Application of Radon. Frank E. Simpson, M. D., Chicago

9. Supplementary Report on Carcinoma of the Larynx. Douglas Quick, M. D., New York City

10. Cancer Conferences: Theory and Practice. Edward H. Skinner, M. D., Kansas City

11. Angiosarcoma of Bone. Harry Hauser, M. D., Cleveland

12. Roentgen Therapy in Carcinoma of the Breast. William E. Howes, M. D., Brooklyn, and Herman Bolker, M. D., Brooklyn (by invitation)

13. Carcinoma of the Breast. Frank E. Adair, M. D., New York City

14. The Treatment of Infected Hemangiomata. Ernst A. Pohle, M. D., Madison, Wis. (by invitation)

15. The Weak Radium Needle Technique. Charles L. Martin, M. D., Dallas, Texas

16. Irradiation of the Long Bones for Gynecologic Bleeding. John S. Bouslog, M. D., Denver, and John R. Evans, M. D., Denver (by invitation)

17. Standardization of Clinical Groups in Carcinoma of the Cervix. Henry Schmitz, M. D., Chicago

18. Radium Treatment of Carcinoma of the Cervical Stump. Robert E. Fricke, M. D., Rochester, Minn., and Harry H. Bowing, M. D., Rochester, Minn.

19. Irradiation of Carcinoma of the Cervix During Pregnancy. Abraham Strauss, M. D., Cleveland

20. Further experience in the Treatment of Cancer of the Cervix by Interstitial Irradiation with Long Platinum Needles. George W. Waterman, M. D., Providence, R. I. (by invitation), and Herman C. Pitts, M. D., Providence, R. I. (by invitation)

21. The Effects of Radiotherapy as Recorded by Serial Color Photography. Lloyd A. Campbell, M. D., Saginaw, Mich.

22. The Treatment of Bulky Carcinomas of the Skin and Lip by Radiotherapy and Surgery. Howard B. Hunt, M. D., Omaha

23. Tumors of the Nasal Cavity. William S. MacComb, M. D., New York City

24. The Roentgenographic Localization of Skin Portals in Roentgen Therapy. Alfred F. Hocker, M. D., New York City (by invitation), and H. R. Tollefsen, M. D., New York City (by invitation)

25. The Specification of Gamma-Ray Doses in Terms of Roentgens. Edith H. Quimby, M. A., New York City

26. A Measurement of Gamma Radiation in Roentgens. T. N. White, M. D., New York City (by invitation), L. D. Marinelli, M. A., New York City (by invitation), and G. Failla, D. Sc., New York City

27. The Radiosensitivity and Stroma Response of a Transplantable Mouse Carcinoma. A. W. Oughterson, M. D., New Haven, and E. A. Lawrence, M. D., New Haven (by invitation).

FACULTY OF RADIOLOGISTS

The British Association of Radiologists and the Society of Radiotherapists of Great Britain and Ireland have decided to amalgamate under the title of "The Faculty of Radiologists." The work of the Faculty will be carried on at the old office of the British Association of Radiologists at 32 Welbeck Street, London.

BULLETIN OF THE INTER-SOCIETY COMMITTEE FOR RADIOLOGY

THE ECONOMIC STATUS OF RADIOLOGY UNDER SOCIALIZED MEDICINE A REPORT ON ENGLAND*

Everyone who has studied socialized medicine knows the basic principle upon which the panel system operates. All physicians in England are affected in some manner by the present system whether they accept panel patients or not. It may be said that, although the British Medical Association, the Insurance Acts Committee and the Local Panel Committee work together, the established fees, their allotment, and in fact, the entire financial setup are under the control of laymen.

The practice of radiology is affected in England in the same manner that it is in America by a large number of small machines in the offices of general practitioners without adequate training in film interpretation. The recognized radiologists practically all maintain an office for private practice. Many have hospital connections which are honorary appointments, and more than one radiologist may be appointed to a hospital staff.

Under the National Health Insurance Act in Great Britain medical benefit is limited to a general practitioner service defined as "all proper and necessary medical services other than these involving the application of special skill and experience of a degree or kind which general practitioners as a class cannot reasonably be expected to possess." Any specialist services required by an insured person must be the subject of arrangements outside the Act. The only exception to this is ophthalmic treatment. Some approved societies have surplus funds which they are allowed to spend on "additional benefits," one of which is Ophthalmic Benefit. In approved cases the society makes a grant towards the whole or part of the cost of an ophthalmic medical examination and sometimes towards the cost of ophthalmic treatment required. The number of such cases is relatively small.

The British Medical Association and the physicians in Great Britain regard the practice of radiology as a medical specialty and it is recognized by the authorities under the National Health Insurance Act as not being a service to which insured persons are normally entitled gratuitously under the Act. There is excellent cooperation between the British Medical Association and the radiological societies and in its booklet, "Hospital Policy," the Association has set forth its policy in regard to the practice of radiology as it relates to hospitals, private patients and those persons indemnified by some form of insurance.

In England the voluntary hospitals occupy about the same position in medical care as the private hospitals in this country. Omitting entirely anything pertaining to government hospitals it may be said that the majority of hospitalized patients are cared for in those institutions supported wholly by voluntary contributions. The Contributory schemes, in which regular small contributions are received from persons of the National Health Insurance class have some of the characteristics of hospital insurance plans. Some schemes have reciprocal arrangements whereby an individual may be hospitalized in a locality where he is not a contributor.

The National Health Insurance plan does not provide for hospitalization but the cash benefits do allow something for continuance of contributions. The Contributions are not expected to pay in full for hospital care of the individual but to supplement other revenue received in a like manner. Solicitation of funds is made by volunteers and contributors are placed on a contributors list. Some schemes have arrangements whereby an individual may be hospitalized in a locality where he is not a contributor.

The radiologists, the same as other

* Prepared at the request of the Inter-Society Committee for Radiology by S. W. Donaldson, M. D., Ann Arbor, Michigan.

specialists on the voluntary hospital staff, receive no remuneration for their services to the ordinary hospital class of patient. The equipment is owned and maintained by the hospitals which purchase all films and supplies and furnish the technical help. If a fee is collected for radiological consultation, one-third of the amount goes to the hospital to defray their expenses incident to the examination and two-thirds to the radiologist. The British Medical Association's view is that the radiological department should not be managed in such a way as to make a profit for the hospital by the exploitation of the professional services of the visiting radiologist. The recommended method, although it cannot always be carried out, is that patients who are able to pay a fee be referred to the private office of the radiologist.

Patients who receive roentgenologic service in the voluntary hospitals under the contributory scheme pay nothing the same as they do for the services of other specialist members of the staff.

A modified fee list for roentgen examinations for persons who cannot pay ordinary fees has been compiled and approved by the radiological societies and made available to the medical profession and hospitals by the British Medical Association.

Proposals which have so far been made for an extension of medical benefit under the National Health Insurance Act to cover consultant and specialist services indicate that payment for radiological services would take the form of a flat rate (probably one guinea) for the diagnostic service, excluding the use of apparatus and materials incidental to the service.

As a whole, the practice of radiology in England consists of referred private patients who pay a private fee, charity patients and "contributing members" who are examined in the department of radiology in a voluntary hospital, and referred patients who are indemnified by some form of insurance. For these a fee is collected. In the tax-supported institutions either full time or part time salaried physicians furnish radiological consultation.

Patients having sickness or accident insurance should in theory be referred to a private office of a roentgenologist but this is not always the case. Industrial and automobile accident cases are taken directly to a hospital and there receive roentgen-ray service either as a contributor, or an opinion from a staff member or an honorary roentgenologist without the insurance company paying a fee for such service.

The great increase in the number of persons participating in the contributory schemes tends to divert private practice to the hospitals. Also the present trend is for a greater number of persons in a higher wage earning bracket to come under some form of government insurance. These two factors affect the entire medical profession as well as the specialties. Among the specialties the fees allowed for insurance cases is at a reduced rate.

I wish to express my appreciation and thanks to the officials of the British Medical Association and to those radiologists in England who aided me in obtaining information included in this report.

ILLINOIS STATE MEDICAL SOCIETY

The Section on Radiology of the Illinois State Medical Society will hold its next meeting at Rockford, Illinois, May 2–4, 1939. Dr. Warren W. Furey, 6844 Oglesby Avenue, Chicago, is Secretary of the Section.

CONFERENCE OF EASTERN RADIOLOGISTS

At the Annual Midwinter Conference of Eastern Radiologists held in Washington, D. C., February 10 and 11, 1939, Dr. David R. Bowen was elected Honorary Chairman of the General Committee and Dr. Joseph F. Elward Recording Secretary of the General Committee.

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers as space permits.

SYNOPSIS OF DIGESTIVE DISEASES. By John L. Kantor, Ph.D., M.D., Associate in Medicine, Columbia University; Gastroenterologist and Associate Roentgenologist, Montefiore Hospital for Chronic Diseases, New York. Cloth. Price, $3.50. Pp. 302, with 40 illustrations. St. Louis: C. V. Mosby Co., 1937.

This book is one of a series of synopses in various special fields of medicine. The expressed design of the author is to present simply, clearly and concisely the essential facts concerning the diseases of digestion, including both their diagnosis and treatment. Obviously the volume is addressed more particularly to students and novices in gastroenterology, for both of whom it will serve as a highly condensed and easily portable text. Because it is so condensed and because the author is qualified by experience to select and present those facts he deems essential, the book is scarcely subject to critical analysis.

B. R. KIRKLIN

L'EXPLORATION RADIOLOGIQUE POST-OPÉRATOIRE DE LA VOIE BILIAIRE PRINCIPALE. Par B. Desplas, P. Moulonguet et P. Malgras. Paper. Price, 40 fr. Pp. 120, with 40 illustrations. Paris: Masson et Cie, 1938.

Exploration of the bile ducts by the surgeon is difficult and often unsatisfactory, and calculi in the ducts as well as other abnormalities frequently escape detection. To reveal such conditions postoperative angiocholegraphy has been employed successfully, and this book is an exposition of the method.

In the opinion of the authors, the examination should be made as early after operation as is practicable, which ordinarily is from the fourth to the tenth day. Various opaque fluid media, including lipiodol, tenebryl, hippuran, and di-iodo-methane-sulfonate, are available for injecting the ducts. None of these solutions is without fault, but the authors prefer lipiodol, which is commonly employed, or tenebryl. Injections are made with a 20 cc. glass syringe with a bluntly conical tip of the urologic type. One item of preparation is considered obligatory: the patient must have fasted from the evening before the day of examination. Many other technical details are, of course, requisite.

Successive chapters in the book describe the normal appearance of the ducts, the incidents and accidents of angiocholegraphy, lithiasis of the ducts, icterus without obstruction, chronic pancreatitis, cancer of the pancreas, the effects of acute pancreatitis, and external biliary fistula. The illustrative reproductions of roentgenograms are remarkably clear and instructive, and the text is comprehensive without tiresome reiteration. In short, the volume deserves unstinted praise, and will be appreciated by roentgenologists everywhere.

B. R. KIRKLIN

I QUADRI RADIOLOGICI DELLE INVAGINAZIONI DEL TUBO DIGERENTE. By Dott. Bruno Bonomini. Paper. Price, L. 30. Pp. 114, with 82 illustrations. Belluno: Casa Editrice Libraria A. Salvador, 1937.

After a brief history of the study of gastrointestinal invaginations, Bonomini illustrates the anatomy of various types of this lesion. In the roentgen examination the author prefers roentgenoscopy, but the type of screen examination varies with each case, depending on the patient's condition, the probable site of the lesion, and the duration of the obstruction. He illustrates and discusses the roentgenologic findings in both the common and rare types of invaginations and supplements his own findings by abundant references. The book should be of interest to all roentgenologists active in gastroenterology.

E. T. LEDDY

THE RHEUMATIC DISEASES. A Course of Lectures Arranged by the Medical Staff of the St. John Clinic and Institute of Physical Medicine. Edited by Sir Leonard Hill, M.B., LL.D., F.R.S., Director of Research, St. John Clinic and Institute of Physical Medicine and Consultant to the Rheumatic Unit at St. Stephen's Hospital (London County Council), and Philip Ellman, M.D., M.R.C.P., Physician to St. John Clinic and Insti-

tute of Physical Medicine and Consultant Physician to the Rheumatic Unit at St. Stephen's Hospital (London County Council). With a Foreword by Sir Arthur MacNalty, K.C.B., M.D., F.R.C.P., Chief Medical Officer to the Ministry of Health. Cloth. Price, $4.00. Pp. 270, with 46 illustrations. Baltimore: William Wood & Company, 1938.

This volume is a collection of lectures given in 1936–1937 on the rheumatic diseases by the staff of the St. John Clinic and Institute of Physical Medicine and by authorities from elsewhere who gave their help. The lectures were attended by a large number of post-graduate students, the majority of whom were in general practice. On completion of the course, requests were made by the students and others who attended that the lectures be made available in book form. They have been modified to ensure, as far as possible, continuity and suitability for publication. As the editors state in their preface, there is some overlapping of subject material, but this is inevitable in a book of this form. It is true, too, as they state, that the presentation is essentially a practical one and is sufficiently comprehensive although it is not an exhaustive treatise. Some divergence of opinion of the various authors is found but there is no controversial tendency which might be confusing to the reader.

Twenty authors contribute. The subjects of the first three lectures are the social and economic aspects, an etiological and clinical survey, classification and clinical types and the general incidence of chronic rheumatic diseases. An excellent lecture is contributed by Leonard Findlay on the acute rheumatic diseases in childhood. Others follow on the pathology of the rheumatoid type of arthritis and of rheumatic fever, the nose and throat and pelvic sepsis in relation to rheumatic disease. G. T. Calthorp contributes the lecture on the roentgenological findings. He subdivides arthritis into four groups: osteoarthritis, rheumatoid arthritis, gout and infective arthritis. In the last are included those patients in whom the causative agent is unknown as well as those in whom gonorrhea, tuberculosis, syphilis, etc., are the etiologic factors. Other subjects are rheumatic disease of the spine, sciatica and brachial neuralgia, and antistreptolysins and blood uric acid in rheumatic diseases.

Therapy is well covered by lectures on the physiological action of the methods used in physical medicine in rheumatic diseases, the indications for light therapy, the technique of treatment by local and general ultraviolet irradiation of the skin, hydrotherapy, drug, orthopedic and surgical treatment.

As a practical guide for the general practitioner this book is invaluable. It should also be an aid to the roentgenologist as a not too complete text to supplement his general knowledge of the rheumatic diseases. It should be a very useful addition to the library of the physical therapist.

Ralph S. Bromer

Laboratory and Clinical Studies, Vol. xviii. From the Memorial Hospital, Huntington Fund for Cancer Research and Douglas Research Laboratory. Paper. New York City, 1937.

This volume is made up of thirty-four reprints of scientific articles published during the year 1937 by twenty-eight physicians and research workers connected with the Memorial Hospital, the Douglas Research Laboratory and the Huntington Fund for Cancer Research in New York City. Although each contribution touches on some phase of malignant disease, four deal with pathology; four with laboratory experimentation; six with physics; two with chemistry; seven with radiology and eleven with clinical and teaching problems. The authors are recognized authorities in their respective fields and consequently the volume contains an excellent cross section of recent progress in one of the best centers for the study of cancer.

Most of the papers by laboratory workers are of interest only to those with a scientific turn of mind but every radiologist can profit by reading "Further Studies on the Rate of Recovery of Human Skin from the Effects of Roentgen or Gamma-Ray Irradiation" by Quimby and MacComb. Other articles of great practical value are Adair and McLean's report of 2,782 patients with tumors of the peripheral nervous system, a series of papers by Barringer, Ferguson, Dean and Keyes on the diagnosis and treatment of genitourinary tumors and a series by Hayes E. Martin and MacComb on the treatment of cancer of the lip, mouth and larynx. The plan of placing all of the work from a recognized center in one compact volume is to be highly commended since it greatly simpli

fies the problem of the busy physician who wishes to keep himself well informed.

Charles L. Martin

Curieterapia in dermatologia. By Prof. Vincenzo Palumbo, Direttore Instituto Radioterapico Italiano. Paper. Price, L. 36. Pp. 87, with 76 illustrations. Belluno: Casa Editrice Libraria A. Salvador, 1937.

In the first part (pp. 1–39) of this short monograph, Palumbo discusses the physical foundations of radium therapy and describes and illustrates various applicators useful in the treatment of dermatologic lesions. In the second part (pp. 39–87) the clinical results to be obtained by judicious treatment are illustrated by numerous "before and after" photographs. This book has no bibliography and in the text itself one rarely finds mention of an American author. The book is interesting, however, to dermatologists and radiologists who may wish to know what is being done and accomplished in one of the foremost Italian clinics.

E. T. Leddy

Il radium nella cura dei tumori maligni delle prime vie aero-digestive. By Prof. C. Torrigiani, Direttore servizi di otolaringoiatria, RR. Ospedali Riunti, Firenze, and Prof. V. Palumbo, Direttore Istituto Radioterapico Italiano, Firenze. Paper. Price, L. 30. Pp. 134, with 68 illustrations. Belluno: Casa Editrice Libraria A. Salvador, 1937.

This monograph, with a preface by F. Sluys and a résumé in Italian, French, German and English, summarizes the combined experience and observation from twenty-five years' active collaboration of the authors. The book, which is essentially clinical, describes and illustrates those methods which in their experience the authors have found to be most efficacious in treating the various lesions.

"We think that the most important rule in the fight against malignant tumours is the following: *we must employ larger surgical proceedings and radiotherapy of greater intensity than the clinical data would lead us to consider sufficient. If this statement is right*—as we are sure—*for surgery, it appears still more necessary with regard to radiotherapy, which*, according to our belief, *must always reach its maximum.*"

"The general conditions of patients must be the basis for the practical fulfillment of radiation therapy.

"The method of the protracted-fractional dosage gives us the possibility of fulfilling these conditions: the reacting powers of the organism are kept efficient; consequently the radiation dose can be raised to its highest degree."

These foremost Italian specialists have here presented a book that all radiotherapists may well read with interest and profit.

E. T. Leddy

DEPARTMENT OF TECHNIQUE

Department Editor: Robert B. Taft, M.D., B.S., M.A., 105 Rutledge Ave., Charleston, S. C.

PROCESS AND APPARATUS FOR ROENTGEN PHOTOGRAPHY*

By MANOEL de ABREU, M.D., *Radiological Consultant, Tuberculosis Dispensaries*
RIO DE JANEIRO, BRAZIL

INDIRECT roentgenography or fluorography, which we call roentgen photography, has been used since 1909 and 1910 in the United States by Cole and Leven, and Commodon in France, with their remarkable trials with roentgen cinematography. Our own researches date from 1924 and have related to the utilization of an inexpensive process in mass survey work. The first Thoracic Census Centers were installed at Rio de Janeiro at the end of 1936 and beginning of 1937.

Roentgen photography employs a combination of photographic apparatus, fluorescent screen and roentgen tube which are conjoined and move upward and downward, fixed on one or two balanced standards.

The technique varies according to the installation, high voltage, the roentgen tube, the fluoroscopic screen and the objective of the photographic machine. These elements are combined in such a way as to obtain a print presenting the whole scale of shading for the study of the mediastinum and pleuropulmonary fields.

Anodes should be water cooled, which allows the apparatus to work for a long time without excessive overheating. We use a small ventilator on the water sphere which keeps the tube permanently cool. We hope to use in the future the tubes with rotating anodes of 20 and 40 kw., if these are of a construction and work suitable for the intense work of the Thoracic Census Centers. The technique is as follows: 50 ma., 85 kv., 0.015 sec. as a medium average, twice per minute, 120 times per hour. We believe that under those conditions the life of the tubes should be, if not unlimited, at least very long. We shall probably be able to obtain 50,000 roentgen photographs with the same tube.

We have successfully tried the fluoroscopic Superastral Siemens and Patterson G. E. screens, both of the latest model. They are very luminous and show a spectrum in which predominate rays from yellow to green and extremely fine grade. They should have a dimension of 40×40 cm.

From the Siemens screens we had the yellow varnish taken off from the lead covered glass (soluble in alcohol) which increases its actinic luminosity by about 30 per cent. The absence of the protecting varnish against intense light does not cause any inconvenience, so that the screen remains at the wide base of the light proof pyramid.

Since our first experience in the beginning of 1936 we use an objective of short focus of 1:1.5 of Zeiss. We expect to receive objectives of a larger opening of f: 0.85, to continue our experiments. Besides luminosity, the optic system should produce pictures at least of 2.4×2.4 cm., because with a smaller surface we do not obtain sufficient detail. Objectives of the usual type 1:1.5 or 1:1.2 are quite satisfactory, seeing that they are obtained by fluorography with rapid exposure from

* Manuscript edited and revised by D. O. N. Lindberg, M.D., Decatur, Illinois.

0.015 to 0.1 second for the thorax of an adult of medium thickness.

We have two essential optical phenomena which are of interest in roentgen photography: the shadow and penumbra and the luminous concentration of the objectives (see Fig. 1).

The roentgen tubes possess a focus or impact area whose square surface varies from 1 to 36 mm. Generally these focusses are of 16 to 36 mm.², corresponding to the linear tubes of 10 to 15 kw.

As a focus is not a geometrical point but a surface of radiant emission, there occurs the phenomenon of shadow and penumbra, whose photographic expression causes the greater or lesser clearness of the pictures.

The penumbra in thoracic teleroentgenography should not exceed 0.4 to 0.5 mm. If longer, the pictures of the organs or the processes distant from the film lose their necessary clearness. The tubes of 10 kw. of 16 mm.² focus cause a penumbra of 0.44 mm. and those of 15 kw. of 36 mm.² give a penumbra of 0.6 mm.

The following are the formulas which give us rapidly the value of the penumbra P in function of the various geometrical elements:

DF—distance of tube from the tube screen.
W—distance of tube object.
V—distance of film object or screen.
O—object.
F—focus of tube.
X—shadow of penumbra.
S—shadow.
P—penumbra.
Y—extension of the show less extension of focus.

$$X=\frac{W}{O}-\frac{DF}{X}$$

$$Y=\frac{W}{OF}-\frac{DF}{Y}$$

$$P=X-Y-F$$

Now roentgen photography reduces the surface of 40×40 cm. of the screen to 2.4 ×2.4 cm. The reduction of 16 diameters or of 277.7 times square (objectives of short focus, placed at 90 cm. from the object). This reduction reaches proportionally the shadow and the penumbra, making the latter 16 times smaller along the whole border of the shadow.

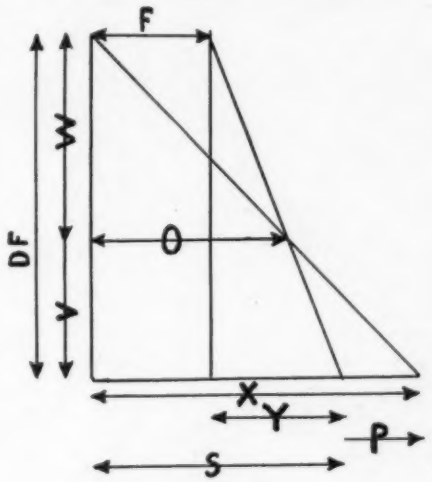

Fig. 1

Measures of penumbra which are of practical interest:

Teleroentgenography, Focus 36 mm.²

Distance Tube-Film	Penumbra Maximum
3.0 m.	0.43 mm.
2.0 m.	0.6 mm.
1.5 m.	1.0 mm.

Roentgen Photography, Focus 36 mm.²

Distance Tube-Film	Penumbra Maximum
1.0 m.	0.094 mm.
0.8 m.	0.125 mm.
0.6 m.	0.19 mm.
0.5 m.	0.25 mm.

The roentgen photograph shoul not bed smaller than 2.4×2.4 cm. so as to facilitate the roentgenological interpretation, which surface can practically and usually be obtained by means of the usual installations for a medium exposure of 0.15 of a second. Only in cases of installation of small yield would it be possible to increase the distance of the film screen or photographic machine screen, so as to obtain a surface of luminous concentration 2.3 or 4 times less: under these conditions one might obtain a roentgen photograph with 25 ma. and 70 kv. in 0.1 of a second. We do not advise the

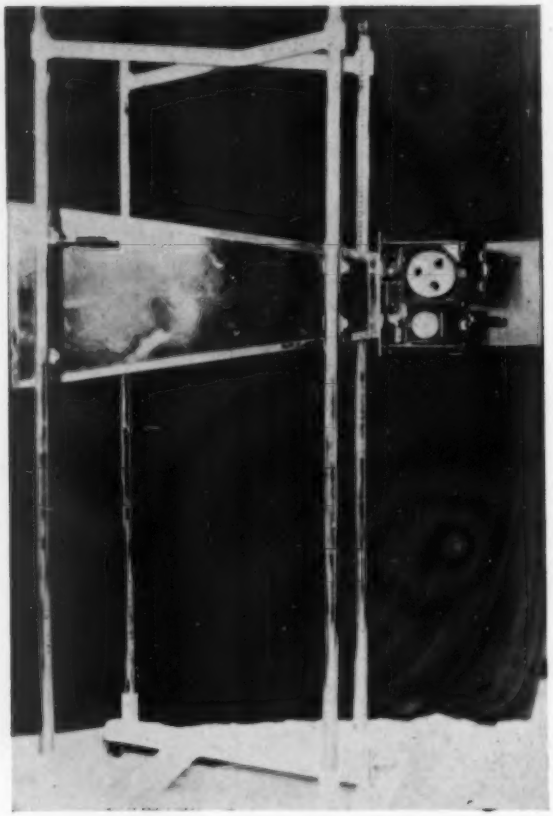

Fig. 2

practice of image reduction without large compensation in connection with its exposition as objectives of short focus (5 cm.) only increase the luminous concentration at the cost of an excessive distance.

One of the principal factors in obtaining roentgen photographs is the emulsion. The film of the series Pan, sensitive to red, and the orthochromatic ones in general, do not give a satisfactory result. Double emulsion anti-halo films having great sensitiveness for the greenish fluorescence of the fluoroscopic screen, of the type Isochrom F is used in the Bureau of Census in the Rua do Rezonde. We use Isochrom F films in tins of 60 m. Six metallic reels of 1.5 m., type Contax, light proof, are charged, which suffice for the daily requirement.

All handling (reeling and development) is done in perfect darkness so as to maintain the white or transparency.

The development and fixing are effected in special Contax celluloid basins for films of the Leica type.

Every meter of this film costs at present 20 cents: there are 23 prints per meter which makes the cost less than one cent each.

The latest model of our apparatus constructed by the firm of Siemens is to be seen in the Sanitary Center No. 3 of Public Health, in the Central Naval Hospital and in the Health Department of Victoria (see Fig. 2). Some will shortly be placed in the Central Military Hospital, at the Public Assistance Department, at the General Polyclinics of Rio de Janeiro, at the Service of Prevention of Tuberculosis and at the Municipal Infant Parks of San Paulo, etc.

This apparatus shows the following features:

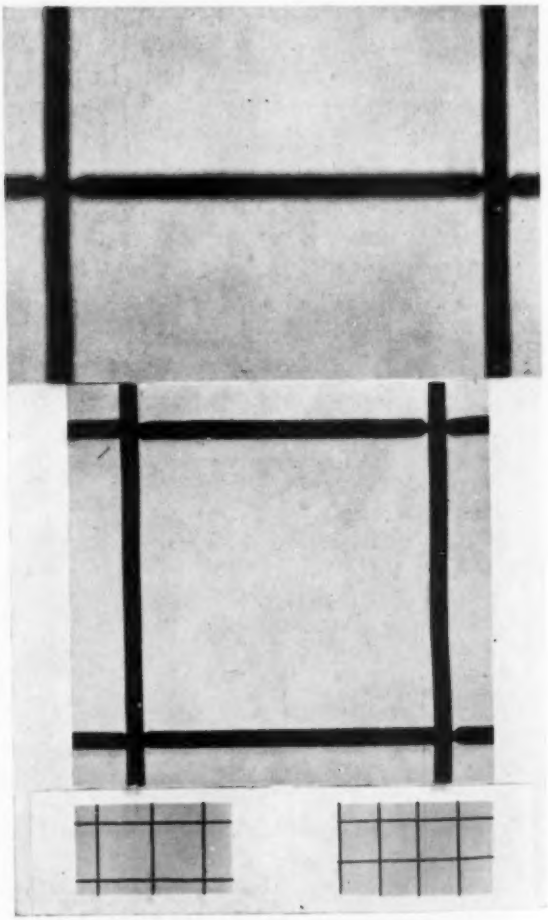

Fig. 3

(1). A very well balanced standard consisting of four nickelled tubes between two frames.

(2) Pyramid light weight support balanced by counterweights.

(3) Photographic machine fixed on a system which permits it to slide and revolve in two senses, so as to allow movements for centering and focalizing.

(4) Centering and focalizing board with two wires crossed vertically, which can be placed on the fluoroscopic screen drawer to obtain perfect focalization.

Technique of Centering and Focalization (see Fig. 3). After removing the fluoroscopic screen, one places the focalizing board and works the photographic machine on a sliding and rotating system, until the cross-

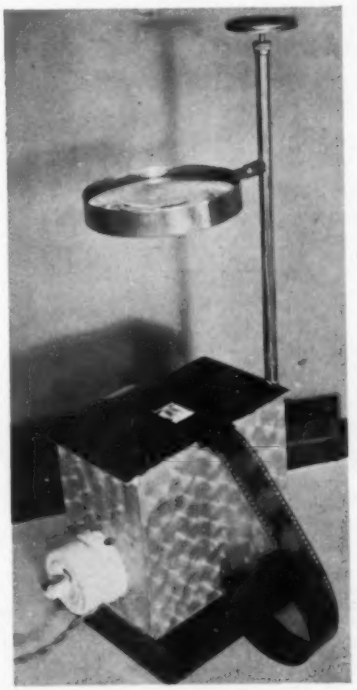

Fig. 4

ing of the wires is perfectly focalized in the center of the telemeter. Then the focalizing board is replaced by the fluoroscopic screen.

The technique of the collective fluorography according to our experience is as follows:

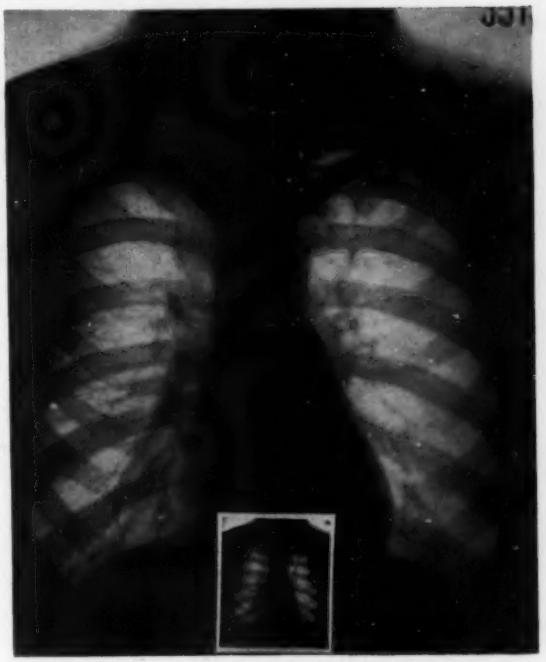

Fig. 5

Constant elements:

Linear tube 10 kw.
Siemens Superastral screen.
Leica, Contax or Exacta photographic machine, objective 1:1.5.
Distance of tube-screen: 60 cm.
Distance of machine-screen: 90 cm.
Focalizing and centering with telemeter.
Film Isochrom F.
50 ma.
85 kv.

For children at the pre-school age we use 100 ma. and 100 kv., with instantaneous exposure of 1/30 second.

1:1.2	less 60%
1:1	less 100%
1:0.85	less 300%

At the beginning of our work at the German Hospital we used a tube-screen distance of 80 cm. After that we went to 120 cm., adopting finally the distance of 60 cm., after having made studies on the phenomenon of penumbra. This distance can be reduced to 50 cm. without unsharpness. Only in cases of prints for large enlargements of projections would we prefer

a tube-screen distance of 100 to 120 cm.

The reading and interpretation of prints is done in a special negatoscope (see Fig. 4), supplied with a lense or system of lenses, of large diameter for the binocular vision and of very slight convexity, that is, of an enlargement of 2 to 3 d at the most.

We studied also a special micrometric apparatus to be constructed, whose quadrants show the measures multiplied by 13, 5, 14, 0 and 15.0 times for estimating the cardiac, aortic, etc., diameters. In these scales, the divergent enlargement of the rays and fluorographic reductions are corrected.

We have experimented with a new collective photographic machine constructed in Rio, whose features are as follows:

Film reel for 60 meters.
Extraluminous objective 1:1.2.
Light proof receptive reel, removable at any moment when cutting film.
Permanent focalization (fixed machine in the apparatus).
Automatic numeration.
Strength and portability for intense collective work.

Roentgen photography is a photographed, documented roentgenoscopy. It does not replace teleroentgenography which contains more detail, nor roentgenoscopy which studies cinematics. It is a new process of wider application whose practical results are of undeniable value. Its greatest advantage is economy. While roentgenography of the thorax uses films of 30×40 cm., hence very expensive and costly, roentgen photography uses films of about 2.4×3.6 cm. (see Fig. 5), whose sensitive surface is more than 270 times smaller, seeing that the former have sensitive coatings on both sides. Its cost is 100 times less, that is to say, almost nil, which makes its application on a large scale possible.

VOL. 41, NO. 4

A SIMPLE COMPRESSION METHOD FOR MUCOSAL STUDY*

By FRANK HUBER, M.D., *and* FRANCIS H. GHISELIN, M.D.
NEW YORK CITY

BY COMBINING two easily available accessories with any combination roentgenographic and roentgenoscopic table we have devised an efficient, convenient and inexpensive procedure for controlled compression studies of the mucosa of the stomach and duodenum in the prone position.

The Chaoul pneumatic compression apparatus in its cloth container is strapped, not to the patient, but directly over the 5×6 inch aperture in a flat metal shield. This shield is fixed to the table top, either by its own weight or by an adhesive substance. Its aperture is centered to the center of the Potter-Bucky diaphragm so that shifting of the casette in the tray allows four exposures on one 10×12 inch film. Permanent location of the shield may be indicated by marking on the table top.

FIG. 1. Setup for roentgenoscopy. Note that pneumatic bag is not yet inflated.

After ingestion of the required amount of barium, small or large, the patient, in the prone position, is postured, roentgenoscopically, so that the part to be studied is precisely centered. The roentgenscopic tube is below the table and the screen above. Under roentgenoscopic control the exact amount of compression can be regulated by alternate inflation and deflation of the Chaoul apparatus. When a satisfactory roentgenoscopic image is obtained, the roentgenoscopic tube and screen are displaced, the Potter-Bucky tray is then brought into position under the shield aper-

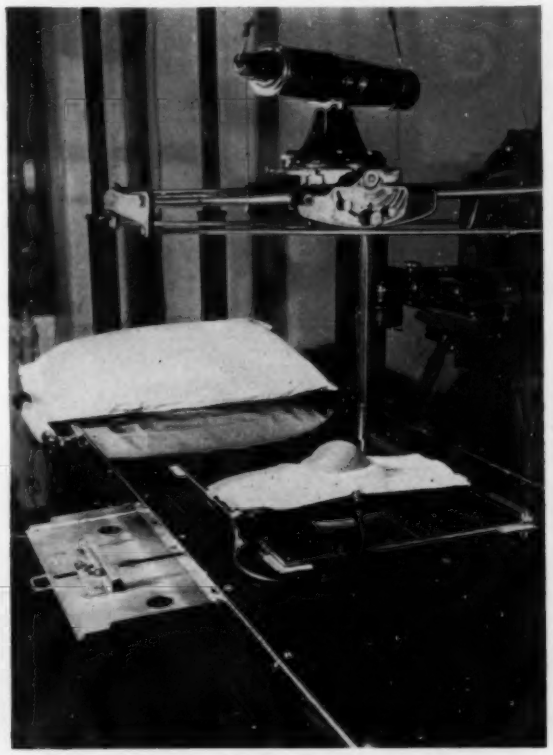

FIG. 2. Setup for roentgenography. Pneumatic bag has now been inflated.

* From the Department of Radiology, Lenox Hill Hospital, New York City, William H. Stewart, M.D., Director.

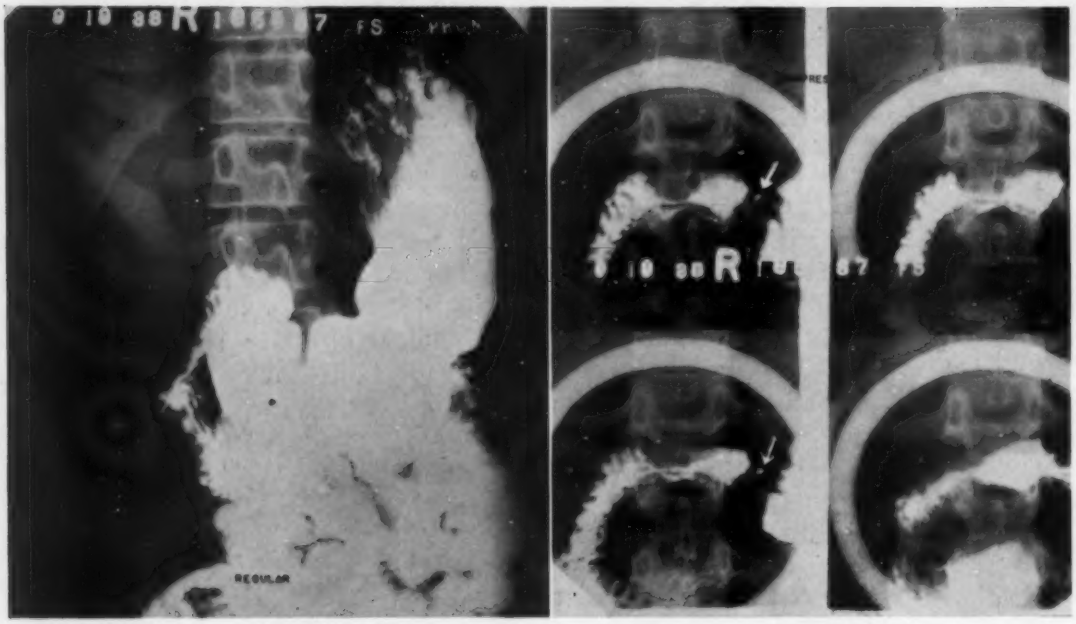

Fig. 3. Demonstration of pyloric ulcer by compression.

ture and the roentgenographic tube is centered above.

A multigram is then made on a 10×12 film by manually shifting the casette serially to the four corners of the tray. This is followed by a second multigram after complete deflation, more or less as a control. With a single tube installation manipulation is necessarily more complicated and prolonged but still feasible since the degree of compression is quite constant. The patient's weight is usually sufficient to insure a constant degree of compression, merely by gravity. If necessary, an ordi-

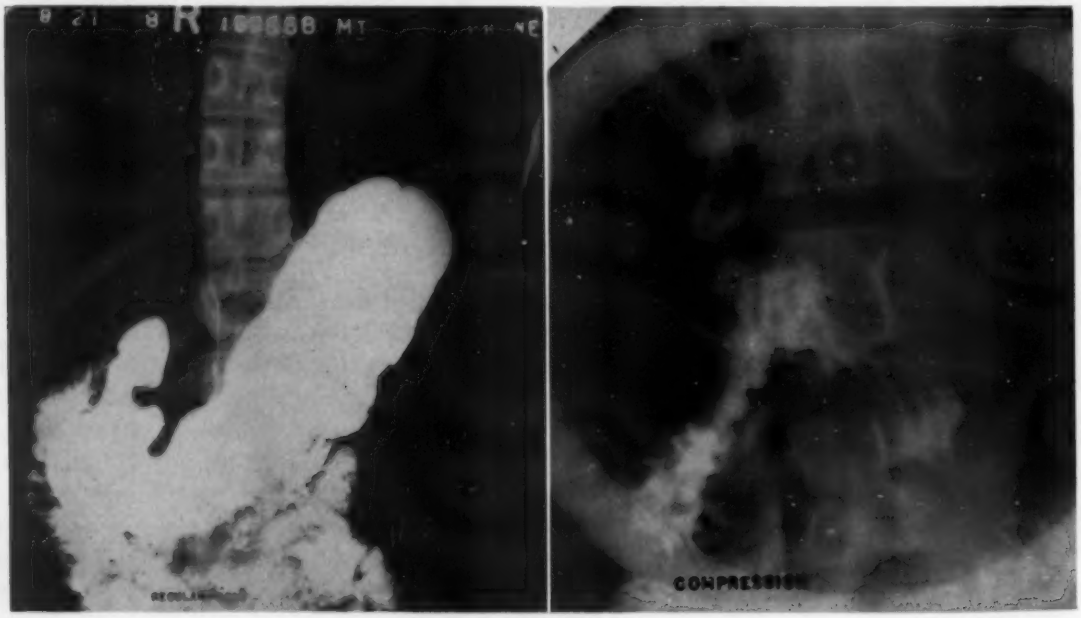

Fig. 4. Demonstration of normal duodenal mucosa by compression.

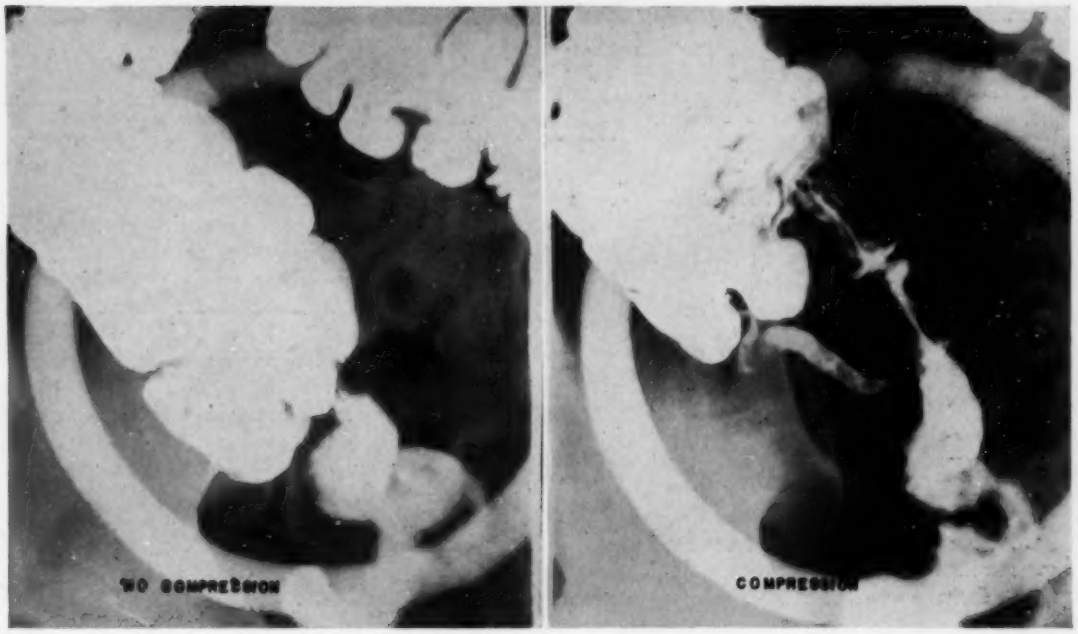

Fig. 5. Study of ileocecal region.

nary compression band may be used to prevent the patient drawing away from the source of pressure. With thin subjects and small lesions, less compression and consequently slower inflation are required. Routine use has shown that the method is applicable even to heavy patients.

A quick change-over switch allows spot or flash film work at any time with the tube below the table. Single exposures instead of multigrams can, of course, be made with or without the metal shield.

The only obligatory technical factor is one-half second or less exposure for each individual roentgenogram. A fixed grid is advisable for roentgenoscopy.

This method has been found to be satisfactory in the investigation of lesions of the stomach and duodenum, particularly in the demonstration of small ulcer craters and marginal ulcers, and in differentiating inflammatory from neoplastic changes. Only after demonstrating an intact mucosa can one rule out all organic pathology, either ulcerative or neoplastic. It may further be utilized in the investigation of the ileocecal region or in any other situation where compression in the prone position is necessary. Additional recommendations are its simplicity and low cost.

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

HEAD

Faber, William M. The nasal mucosa and the subarachnoid space. *Am. J. Anat.*, Nov. 15, 1937, *62*, 121–148.

Foreign materials injected into the subarachnoid space of animals may pass into the mucosa of the nasal cavities and be found free in the nasal cavity or even extending to cervical lymph nodes. The opposite route connections may also hold; potassium ferrocyanide and iron ammonium citrate have been found to pass through the mucosal epithelium and extend into the subarachnoid space. In cases of certain nasal infections, pus has been found to extend along the lymph sheaths of the olfactory nerves to the pia-arachnoid meshes. With great pressure, cerebrospinal fluid may drain outward along these channels, thereby producing a cerebrospinal fluid rhinorrhea.

The author emphasizes the fact that this pathway does not seem to be the one chosen by the virus of poliomyelitis. This virus seems to have a predilection for the nasal mucous membrane but in extending to the spinal cord it does not seem to follow the perineural lymph channels; instead it penetrates into the neuraxon and travels, by multiplication, along it.

The author performed a variety of experiments on living rabbits. He confirmed the findings that aqueous 1 per cent ferrocyanide and iron ammonium citrate, when dropped into the nasal mucosa, can be found on the olfactory bulbs and the meninges of the cranial cavity within an hour. It was also found in the regional cervical lymph nodes. Oily solutions, such as brominized olive oil, showed much less penetrating power; of 12 rabbits and 1 monkey, studied with the use of it, only 1 rabbit showed oil in the cranial cavity (region of the hypophyseal fossa) and only 1 rabbit showed the presence of oil in the regional cervical lymph nodes. After plugging the posterior nares and using a spray of mineral oil containing menthol and camphor, the rabbits being etherized, 3 of 11 showed oil in the cranial cavity and 1 showed penetration of dye into the cervical lymph nodes. Therefore, time and trauma to the mucous membrane seemed to increase the possibilities of absorption. Serial sections were studied of the olfactory bulb regions and the nasal mucous membranes and regional tissues after injecting thorotrast into the foramen magnum or applying it to the mucous membranes of the nose or similarly using potassium ferrocyanide and iron ammonium citrate. These histological studies showed that the aqueous reagents pass through the olfactory mucosa through rather definitely defined channels in the epithelium and can be found in lymph vessels and the connective tissue spaces of the mucosa and also in the tissue spaces of the perineural sheath of the filaments of the olfactory nerve. The lymph vessels ultimately drain into the regional cervical lymph nodes while the perineural spaces of the filaments of the olfactory nerve communicate with the subarachnoid space, particularly in the region of the olfactory bulb. This route is reversed when solutions are injected into the foramen magnum; thorotrast was found to reach the regional cervical lymph nodes within thirty minutes. Direct communication between the subarachnoid space and the lymphatic vessels of the nasal membrane was not evident.—*A. A. de Lorimier.*

Freeman, Walter. Effect of injections of colloidal thorium dioxide on the ventricles and subarachnoid spaces. *Arch. Neurol. & Psychiat.*, Aug., 1937, *38*, 340–347.

This analysis concerns studies of 10 cases; in 2, the biopsy material was gained, surgically; in 8, by post-mortem study. The time intervals, after the injections of colloidal thorium dioxide into the ventricles, ranged from one hour to two months.

The author has studied other cases where sheets and plaques of thorium dioxide were observed for three months and longer, clinging to walls of the ventricles. He states that after two days, the colloidal characteristics of the solution are lost (probably due to absorption of the "dextrin" colloid) so that the thorium dioxide becomes flocculant. If there is no obstruction, it is eliminated along the usual pathways eventually reaching the venous sinuses, etc.

(In 1 case, particles were observed in the arachnoid villi and the longitudinal sinus itself, mixed with a terminal clot.)

Exudative inflammation, with swelling of the choroidal epithelium and slight leukocytic reaction, was noted as early as one hour following injection. Within twenty-four hours, this reaction was marked, there being conspicuous leukocytic infiltration, edema, hyperemia and even some destruction of epithelium. Macrophages were found and these, as well as the leukocytes, contained granules of thorium dioxide in their cytoplasm. Such changes in the choroid were practically clear within three days.

The ependyma showed no effect until after twenty-four hours when glistening nodules (the thorium granules) were found on the surface. Microscopically, the cells showed swelling and beginning exfoliation. Leukocytes and macrophages, laden with granules of the thorium, were numerous. The deeper layers showed little or no reaction.

In a case of obstructive hydrocephalus, four days after injection, the ventricles were found to be filled with pus; hyperemia was marked with minute focal hemorrhages in the ependymal lining.

In another case of ventricular obstruction, due to tumor in the pons, two months after injection, the ependyma was largely absent, and replaced by a sheet of histiocytes (containing particles of thorium). There was no perivascular reaction but histiocytes were found even in the deeper layers.

Clinically, reaction of the meninges was suggested by headaches and some stiffness of the neck within twenty-four hours of the time of injection but, histologically, evidence was not seen until that interval. There was leukocytic exudation with many macrophages. These appeared to have arisen from the ventricles, rather than locally. By the end of two days there were few leukocytes but more macrophages. In 1 case, dying two months after injection, the meninges about the base were thickened, but there was no indication of matting. A large proportion of the thorium still remained free. There were macrophages and lymphocytes.

The author concludes that stabilized colloidal thorium dioxide exerts a transitory inflammatory reaction in the choroid plexus, ependyma and meninges, with more serious damage when there is ventricular obstruction. —*A. A. de Lorimier.*

NECK AND CHEST

Malherbe, A. L'infiltration sous écran radioscopique du ganglion étoilé. (Infiltration of the stellate ganglion under roentgenoscopic control.) *Presse méd.*, May 14, 1938, *46*, 770–771.

For this purpose a flexible platinum needle 10–12 cm. long, 8/10 mm. in diameter is used. The supraclavicular area (midclavicle) is prepared, the patient in decubitus dorsal with a cushion under the shoulders so that the head is in forced extension and the face turned to the opposite side.

The musculo-vascular mass in this region is taken, drawn strongly forward and inward and the needle introduced in the direction of the transverse process of the 7th cervical vertebra to a depth of 6 to 7 cm. Under roentgenoscopic control, the needle is passed into the angle between the first rib and the vertebra following the neck of the ribs. With a small diaphragm and moving the roentgen tube from side to side, the depth of the point of the needle in respect to the rib is determined.

The method is particularly used in the treatment of aural noises, both intrinsic and extrinsic.—*M. L. Sussman.*

Beutel, A. Röntgenologische Beobachtungen bei frischen Ösophagusverätzungen. (Roentgen observations in recent esophageal erosion.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Sept., 1938, *58*, 223–227.

Little attention has been paid to the findings soon after the ingestion of corrosive substances. Previous studies have been concerned chiefly with the late manifestations of stricture, location and differential diagnosis.

The author reports the findings in 3 cases of lye ingestion and 1 of acid ingestion. In the former there is mucosal swelling, loss of superficial epithelium and pseudo membranous deposit. There is a colliquation necrosis and a soapy consistency of the tissues. The roentgen findings a few hours after the ingestion are a dilated esophagus with faint tortuous mucosal folds or the folds may be absent, and spasm in the supradiaphragmatic portion.

Corrosive acids cause coagulation of protein, crust formation having the consistency of clay, and finally hemorrhagic ulcerating inflammation. The author's case was observed sixteen days after the ingestion of hydrochloric acid. Eight days before she had vomited a tube-like

structure 25 cm. in length which was the esophageal mucosa. The contour of the barium had a fine dentate appearance due to granulations such as one sees in ulcerative colitis. The esophageal lumen was contracted. Barium studies are not harmful to such patients.—*W. A. Evans, Jr.*

Haenisch, F. Polypöser Ösophagustumor. (Polypoid tumor of the esophagus.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Sept., 1938, *58*, 233–239.

In 1924 the author reported a case with a large benign esophageal tumor. He now reports a second case of this extraordinarily rare condition. It was first observed as a shadow on the right side of the mediastinum incidental to a study of the lungs in a man, aged sixty-four. Mediastinal tumor and aortic aneurysms were considered but with the former case in mind the possibility of an esophageal tumor was recognized and reported. The diagnosis was established by barium studies and esophagoscopy.

The large size of the tumor with the lobulated surface together with the esophageal dilatation pointed to a benign polypoid tumor. The diagnosis could not be made with certainty from the biopsy material obtained at the esophagoscopy. After a course of six deep roentgen treatments the tumor was observed to be smaller, and after further extensive therapy was very much reduced in size. Nevertheless the patient declined and died about ten weeks after the first examination. The autopsy showed that the tumor had completely melted away and no remnant was demonstrable microscopically. There was extensive pneumonia and gangrene of the lungs, secondary to rupture of the esophagus into the right lung. A study of similar cases in the literature shows that such benign tumors carry the same poor prognosis as carcinoma.—*W. A. Evans, Jr.*

Fine, Jacob, Hermanson, Louis, and Frehling, Stanley. Further clinical experience with ninety-five per cent oxygen for the absorption of air from body tissues. *Ann. Surg.*, Jan., 1938, *107*, 1–13.

Ordinary atmospheric air may accumulate or it may be injected therapeutically into various sites in the body and after a period of time there it may become irritating. The authors mention such instances as gaseous distention of the intestines, spontaneous pneumothorax, subcutaneous emphysema, air embolism and encephalographic states. They point out the fact that in case of irritation, the offending agent is nitrogen—for it is slowly absorbed. The oxygen is more rapidly absorbed. Such accumulations cannot always be removed by aspiration. Therefore the authors have tackled this problem by lowering the tension of the nitrogen in the blood stream. This they accomplished by oxygen breathing. They found the partial pressure of nitrogen in arterial blood to be 155 mm. Hg, after one hour of breathing 95 per cent oxygen; 91 mm. Hg, after two hours; 52 mm. Hg, after three hours, and 31 mm. Hg, after four hours.

This type of treatment was used in 5 cases of intestinal obstruction. The accumulations of gas were reduced to such an extent that flatus was passed (likely because of partial collapse of the distended viscera whereby greater muscular turgor and peristaltic activity were gained). In several of the cases subsequent surgical procedures were facilitated. Actual measurements of girth were reduced, even before the passage of flatus—therefore supporting the opinion that some of the gas was eliminated by way of the vascular system. In some instances there was an increase in the girth measurement within the first eighteen hours; this was accounted for on the basis of relaxation of the abdomen and movement of the abdominal viscera downward from diaphragmatic levels. Ultimately, these cases, too, showed decreased measurements. To avoid toxic effects because of too prolonged breathing of the oxygen, the authors recommend interruptions of about a half hour in every four to eight hours. Intermittent administrations of oxygen were given in this manner for as long as thirty-five hours, though shorter periods usually sufficed.

Two cases of spontaneous pneumothorax were so treated. Both showed evidence of "valvular" increments of the gas; the oxygen percentages remained unchanged and there was only temporary benefit.

This treatment was made a routine after encephalography in cases of headache, nausea and general indisposition. Roentgenograms made before and after the breathing of oxygen, in these cases, showed that a maximum of three hours was sufficient for absorption of the bulk of the injected air. If given as a prophylactic, the patients were fit and able to be up within twenty-four hours after this procedure.

At present the conventional treatment of air

embolism consists of placing the patient in the Trendelenburg position. The authors suggest oxygen inhalations for this condition, theorizing that the nitrogen fraction would more readily be absorbed into the blood, after reduction of its balance there. They have experimented with cats but have not been successful in absorbing the emboli with them nor have they applied the method clinically, for treatment of such emboli.—*A. A. de Lorimier.*

Walsh, Thomas W., and Meyer, Ovid O. Coexistence of bronchiectasis and sinusitis. *Arch. Int. Med.*, June, 1938, *61*, 890–897.

The relationship between bronchitis and sinusitis has long been known to otolaryngologists, but the association of these two conditions has not been widely recognized by general practitioners.

In experimental animals, Mullins and Ryder demonstrated aspiration of ink and suspensions of tubercle bacilli from the nares and the antrum into the bronchial tree. They found this even in cases where egress from the nares was prevented and explained the travel as being via lymphatics and venous routes to the right side of the heart and from thence to the lungs. These studies were confirmed by Corper and Robin. Quinn and Meyer found that if iodinized oil was injected into the anterior nares of a sleeping individual, it could be seen fluoroscopically in the bronchi or pulmonary parenchyma by the following morning.

Statistics have varied as to the actual percentages of sinus infections found in cases of bronchial infections. Quinn and Meyer reported that 57.9 per cent of 38 cases of bronchiectasis showed coexistent sinusitis. McLaurin expressed the opinion that the association of bilateral bronchiectasis and paranasal sinus disease is almost constant.

This study concerns amplification of the observations reported by Quinn and Meyer and covers 217 cases of bronchiectasis. Of these, 66.8 per cent were found to have associated sinusitis (as manifested by the presence of gross pus in one or more of the paranasal sinuses). Of these, 58 per cent were males and 42 per cent were females. The oldest patient was seventy-eight; the youngest, six; 66.8 per cent of the cases were under forty and 64.8 per cent claimed onset of symptoms before the age of thirty. In 31 cases, symptoms were said to have dated back to the age of five. Influenza and pneumonia appeared to be the two most frequent causes. In 75.2 per cent, the bronchiectasis involved both lungs; in 68.3 per cent, only the bases were involved. There was no conspicuous predominance of the disease in the right lung. Bacteriologic studies were not considered satisfactory. Only about one-third of the cases were thus studied; streptococci predominated in 28, while Vincent's organisms were found in 8 of the 10 cases in which they were sought.

On the other hand, 52.8 per cent of those cases which did not show any evidence of associated paranasal sinusitis showed involvement of both lungs. Most of these cases antedated their symptoms to some very definite disease. As a group, those not showing associated paranasal sinus involvement were older than those that did.

Most of these patients had no subjective symptoms of sinusitis; hence the importance of the consideration and recognition of such for early treatment of the sinus disease, in cases of bronchitis and bronchiectasis.—*A. A. de Lorimier.*

Elliott, R. W. Subcutaneous emphysema and pneumothorax in bronchial asthma. *Lancet*, May 14, 1938, *1*, 1104–1106.

The author found in the literature reports of only 4 cases where subcutaneous emphysema had resulted as a complication of chronic asthma; none showed pneumothorax. A synopsis of each of these cases is presented.

The additional case being reported was of a woman, aged forty-six, who was studied by the author in December, 1937. She had had attacks of asthma since 1918, at which time she had had pneumonia. These attacks had been increasing progressively in severity, bothering her especially during the winter season, and usually during the night. The night before her entry she had the usual wheezing and noted that the right side of her neck was swollen. This swelling progressed in degree until when examined by the author the puffiness had extended over her chest, face and right arm. "Egg-shell crackling" could be felt and heard with the use of the stethoscope. There was marked cyanosis. Otherwise the clinical evidence was typical of asthma: rapid wheezy respiration with prolonged expirations; bulging at both apices on coughing; wide costal angle; sides of chest hyperresonant with reduction in cardiac and liver dullness, etc. The pulse was shallow and 132 per minute. Adrenalin was given in dosage

of 4 minims (1–1000) every three hours but the general condition became worse. The emphysema extended, involving the whole body, except for the hands and for the legs below the knees; the pulse rate increased to 130–140 and cyanosis became so great that intranasal oxygen was administered continuously. The patient became semicomatose. Roentgenography was performed two days after the onset of these symptoms. A partial pneumothorax was visualized on the right side and large reservoirs of air were seen in the subfascial planes of the chest wall.

Tachycardia and dyspnea continued regardless of administrations of adrenalin and coramine and continuous oxygen administration. The degree of pneumothorax did not appear to be sufficient to account for the severity of symptoms. There was no appreciable deviation in the position of the heart. However, with the hope of benefiting the patient, a needle of an artificial pneumothorax apparatus was inserted into the right pleural cavity. The pressure was 4–5 cm. water; after withdrawal of 350 cc. of air this pressure was reduced to a negative 2–3 cc. water. The severe symptoms continued. Emphysema extended into the tissues of the breast to such an extent that it was feared that gangrene might result. For this reason, two incisions 2–3 in. long each, were made into the tissues of each breast. Nothing was noted until penetrating the deep fascia when there was a sudden explosive burst of air. The symptoms were alleviated within the next twenty-four hours. At one time the patient had complained because she was unable to see, due to puffiness about the eyes. Pockets of air were penetrated with an aspiration needle releasing as much as 6 cc. from each side. In attempting to withdraw blood from one of the brachial veins the syringe filled with air, due to the extensive subcutaneous emphysema of the arms.

The patient was discharged from the hospital at the end of a month. She still had a slight shortness of breath, from the pulmonary emphysema. Though studies were continued during subsequent episodes of nocturnal dyspnea, there was no recurrence of the extensive interstitial emphysema nor of the pneumothorax. The author considers that the explanation of this unusual progression of air might be similar to that given by Boyd in describing interstitial emphysema of the lungs of children having violent coughing with whooping cough. "The air collects in the lymphatics in the form of tiny beads, being seen particularly well under the pleura. The air may pass along the lymphatics to the mediastinum, and from there to the root of the neck."—*A. A. de Lorimier.*

LÉON-KINDBERG, MICHEL, and LAPINE, G. Gomme syphilitique du poumon. (Syphilitic gumma of the lung.) *Presse méd.*, May 21, 1938, *46*, 812–813.

In a case of lues characterized clinically by luetic scars in the palate, perforation of the septum and a positive Bordet-Wassermann reaction, a pulmonary lesion was found which disappeared in three weeks after specific therapy. There was a complete absence of pulmonary symptoms. Roentgenologically, Sergent and Benda say there are three phases of pulmonary gumma: (1) a circular opacity, (2) a cavity, (3) a nodular or stellate scarring.

There were two essential points in the diagnosis of the present cases: (1) the patient was luetic; (2) the response to specific therapy. Gumma has no tendency to spontaneous disappearance.—*M. L. Sussman.*

JULLIEN, L. La place de la radioscopie systématique dans le dépistage de la tuberculose pulmonaire au sein des collectivités. (The place of systematic roentgenoscopy in the investigation of pulmonary tuberculosis in collectives.) *Presse méd.*, June 4, 1938, *46*, 881–883.

Traditional methods of investigation are not applicable to the examination of large groups of individuals. Auscultation takes too long and is too fatiguing to the examiner. Examination for tubercle bacilli cannot be applied to routine work.

Application of roentgenoscopy to only those cases with positive tuberculin reactions is also lengthy because two trips must be made for the tuberculin reaction and two more if negative, for confirmation. The author would use these tests for differentiation only after positive roentgenoscopy.

It is admitted that a film is far more satisfactory but making routine roentgenograms in a collective is too difficult and it is better to have some evidence than none. Roentgenoscopy also gives indispensable information on the diaphragm and on the effect of varied positions of patient and tube.

1. Sieur roentgenoscoped 148,700 soldiers on entrance into the French Army (1926–1937); 273 had lesions thought to be tuberculous and

confirmed by the finding of tubercle bacilli; 277 had definite lesions without tubercle bacilli being demonstrated in the sputum; 675 had lesions thought to be suspicious but not proven.

2. Re-examination six months later showed some new cases.

3. In 19,967 career men in the army, 48 tuberculous cases were found.

4. Of 35,329 reserves roentgenoscoped with 182 thought to be affected with tuberculosis, 122 showed a positive sputum.

These figures indicate the need for roentgenoscopic investigation in schools in addition to proper clinical examination followed by roentgenography in suspected cases.—*M. L. Sussman.*

Rose, Edward, and Hopkins, Henry U. Association of hyperthyroidism with pulmonary tuberculosis. *Arch. Int. Med.*, April, 1938, *61*, 631–645.

Frank thyrotoxicosis and active pulmonary tuberculosis are not commonly encountered in the same patient. Still, there does not appear to be definite antagonism between the two. Parenchymatous and colloid goiters are relatively common in cases of tuberculosis; they may heal as the tuberculosis heals but if the tuberculosis becomes very severe the thyroid gland (and other endocrine glands) may develop diffuse sclerosis. Mild hyperthyroidism not infrequently confuses the diagnosis of early tuberculosis.

Experimentally, many observers have been led to believe that thyroid gland secretions or the administration of thyroid extract assist bodily defenses against tuberculosis. Others have suggested that ablation of the thyroid gland is conducive to the healing processes. Some have expressed the opinion that there is an exhaustion of iodine content in the thyroid of tuberculous cases, though Piazza reported an actual increase in the percentage of iodine per gram weight of thyroid tissue in tuberculous patients. The same difference of opinion has been expressed as regards the changes in metabolism. The importance of cholesterol content of the blood is not established though it is almost constantly increased in hypothyroidism and often decreased in hyperthyroidism. It is often decreased in tuberculosis, especially in the ulcerative forms with exudation.

Actual tuberculous infection of the thyroid gland is very rare (0.1 per cent of 20,758 glands examined at the Mayo Clinic).

Of a series of 1,053 patients with hyperthyroidism, studied at the University of Pennsylvania Hospital, only 14 were found to have tuberculosis (1.3 per cent). During the same period of study (1930–1936) among 729 patients with pulmonary tuberculosis, active or arrested, the incidence of hyperthyroidism was only 1.9 per cent (14 cases). Studies of these patients have led the authors to believe that the administration of iodine to thyrotoxic patients with pulmonary tuberculosis does not tend to precipitate exacerbation of the tuberculosis; thyroidectomy is well tolerated by such patients; the tuberculosis does not hamper treatment of the thyroid, either by surgery or irradiation but alleviation of the thyroid hyperactivity does not seem to influence the prognosis for patients with associated pulmonary tuberculosis.—*A. A. de Lorimier.*

Ameuille, P., Ronneaux, G., Hinault, and Desgrez, H. Quelques cas d'artériographies pulmonaires. (Cases of pulmonary arteriography.) *J. de radiol. et d'électrol.*, Feb., 1938, *22*, 97–102.

Roentgenograms are made immediately after the injection of 8 to 10 cc. of 120 to 140 per cent sodium iodide solution directly into the right auricle. A No. 11 or No. 12 ureteral sound, 60 cm. in length, is introduced into an exposed internal vein in the left elbow and passed, under fluoroscopic control, to the region of the junction of superior vena cava and right auricle. The method permits visualization of the pulmonary vessels, their differentiation from parenchymal and glandular shadows, the analysis of hilar shadows, and the interpretation of mediastinal shadows. It is also possible to study vascular changes in the various pulmonary diseases. For example, vessels about an abscess are fewer but they persist longer and remain more permeable than about a tuberculous process. Circulatory diminution in pneumothorax and profound circulatory changes in bronchial dilatation are shown.

In bronchiectasis the vessels are irregular with poorly defined contours, following the dilated bronchi. In one carcinoma of the lung a complete arrest in the circulation of the middle lobe was shown; in the other, no significant change.

The procedure is not difficult and the sound

may be passed to the beginning of the superior vena cava without danger. The right auricle and, particularly, the inferior vena cava must not be entered.—*M. L. Sussman.*

Enquin, B., and Aguirre, J. A. Dissociation radiographique des ombres intrathoraciques en position frontale. (Roentgenographic differentiation of intrathoracic shadows in the frontal position.) *Presse méd.*, June 25, 1938, *46*, 1028–1031.

Differentiation of dense, relatively homogeneous, mediastinal shadows was made by the use of relatively penetrating roentgen rays, of a Potter-Bucky diaphragm and of factors depending on what is found in the chest rather than the external measurement.

The authors used the following factors: 90 cm. distance, 150 ma., 75 to 82 kv. eff., 1/10 to 4/10 second, Potter-Bucky diaphragm. The procedure has on occasion proved more efficient than tomography.—*M. L. Sussman.*

Debré, R., Lamy, M., Mignon, M., and Welti, J.-J. Le "poumon coquelucheux" et son image radiologique. (The "whooping cough lung" and its roentgenologic image.) *Presse méd.*, June 25, 1938, *46*, 1011–1014.

Traditionally, the anatomic changes in whooping cough are described as discrete and remain localized to the mucosa of the trachea and larger bronchi. For the lung to be affected, the complication of acute or subacute bronchopneumonia is necessary. It is the authors' opinion, however, that simple uncomplicated whooping cough is truly a subacute pulmonary affection.

There is first a peribronchial and perivascular infiltration. Around bronchi and vessels a granulation tissue containing fibroblasts, lymphocytes and a small number of polymorphonuclear leukocytes develops. Hilar glands enlarge. The inflammation extends along lymphatics which are enlarged and filled with exudate. Bronchial and bronchiole mucosa is intact. Later a serous exudate develops in the larger bronchi with epithelial desquamation and swelling of the mucous glands.

Pospichill and Feyrtev think that the bronchial inflammation is first and that plugging of the bronchus may give rise to more or less atelectasis with second degree interstitial pneumonitis.

Satisfactory pathological reports are too few and experimental evidence is contradictory. Clinically, it is felt that the pulmonary affection is primary. Whooping cough is not always afebrile; cases show râles sufficiently frequently to be significant; a definite roentgen shadow is often found. These signs have been thought of as complications but appear more to be part of the disease.

Two cases are shown with roentgen signs; the first with fever, very abundant purulent sputum and a triangular shadow at the right base. In both, lipiodol examination revealed normal bronchi.

The roentgen signs of whooping cough that have been described are modification in shape and movement of the diaphragm, diminution in pulmonary transparency, accentuation of the hilar network. The present authors find, on the right, a subhilar, paramediastinal shadow which may or may not reach the diaphragm. It is not homogeneous. On the left the shadow is retrocardiac and deforms the outline of the heart. The shadows may extend up into the hilar region and above. Pleural involvement may occur. These changes are found in about half of the mild cases and are practically constant in the more serious and prolonged forms.

Differentiation from tuberculosis, abscess and particularly bronchiectasis may be necessary.—*M. L. Sussman.*

Maingot, G., and Bernard, E. Les insuffisance de la radiographie ordinaire en phtisiologie et leur correction par la tomographie. (The insufficiency of ordinary roentgenography in phthisiology and their correction by tomography.) *Presse méd.*, March 16, 1938, *46*, 409–411.

There are three major difficulties with simple roentgenography: (1) The accurate representations of details and contrasts, e.g., as the result of thickness and density of parts, sensitivity of photographic emulsions; (2) the impossibility of analyzing certain shadow superimpositions; (3) the impossibility of appreciating the depth of certain lesions. Tomography, however, preserves contrasts. The best tomographs permit 5 to 7 mm. slices: the thinner they are, the more contrast and transparency since the other shadows are farther away—*M. L. Sussman.*

Loubeyre, J., Porot, Fr., and Destaing. Maladie kystique du poumon. (Cystic dis-

ease of the lung.) *Presse méd.*, Jan. 22, 1938, *46*, 128–130.

The differential diagnosis of cystic disease from an acquired ampullary emphysema in the absence of anatomic or histologic confirmation may be very difficult. The roentgenologic pictures may be superimposable. Considering cystic disease as congenital, the differentiation may be important.

Two cases are reported which are considered to be congenital cystic disease on the following grounds:

1. Clinical
   - A. Long history of delicate pulmonary symptoms since infancy.
   - B. Signs of heredity—the thoracic deformity more marked on the affected side; a dropped, poorly developed shoulder on the same side; a premature kyphosis for the patient's age.
   - C. In Case II, non-tuberculous, recurrent hemoptyses.
2. Roentgenological
   - A. Persistence of abnormal roentgen shadows.
   - B. The multiplicity of annular shadows in a complete lobe, a lung or both lungs which resemble small balloons in a network.
   - C. The partitions are thick and irregular while in vesicular emphysema they are as thin as a hair.
   - D. The presence of a fluid level in one or more of these cavities.
   - E. Pneumothorax permits the cavities to be visualized more clearly since their size and extent are even better visualized than by bronchography. On the other hand, pneumothorax in bulbous emphysema collapses the bullae which reappear when the pneumothorax is absorbed. It is said that the pneumothorax is not dangerous in this condition.—*M. L. Sussman.*

Gross, A. Knotige Knochenbildung bei chronisch kardialen Stauungslungen. (Nodular bone formation in chronic passive congestion of the lungs.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, July, 1938, *58*, 33–39.

Calcified nodules in the lung are most often attributed to an old tuberculous process. Such nodules have also been described following bronchopneumonia, gas poisoning, mycotic infections, and syphilis. Similar nodules are seen in silicosis.

In mitral stenosis, the faulty circulation of blood through the lungs leads to alveolar congestion and there is also lymph stasis. The exudate may become organized about hemosiderin crystals and later calcification may occur. Such cases have been described in the early pathological literature. Salinger reported the first case recognized roentgenologically in 1932. Here there was not only calcification, but actual ossification as shown at autopsy. The author examined the films of all patients with mitral stenosis seen in his hospital between 1930 and 1938, and found 4 such cases, which are reported in detail. One case showed an increase in the size and number of the foci during a seven-year observation period. The nodules are lobulated and exhibit a kind of structure which indicates bone formation. They occur bilaterally and principally in the basal and hilar areas. Recognition of the large nodules is not difficult when their bony structure can be identified. The smaller nodules may be mistaken for calcium deposits or small pulmonary arteries seen in cross section.—*W. A. Evans, Jr.*

Reitan, Håkon. Beitrag zur Röntgendiagnose der Preikarddivertikel und der abgesackten Perikardexsudate. (The roentgen diagnosis of pericardial diverticulum and encapsulated pericardial exudate.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Sept., 1938, *58*, 195–213.

Hart of Dublin first reported a pericardial diverticulum at autopsy in 1837. The author reports 4 cases, 2 with pericardial diverticulum, 1 with dermoid cyst of the pericardium and another with concretio pericardii and encapsulated tuberculous exudate. Three of these cases showed a change in the shape of the shadow during respiration, thus ruling out tumor or any swelling of firm consistency. Bronchial cysts, lymphangiectatic cysts, dermoid cysts and echinococcus cysts have been described in connection with the pericardium. They may change in shape with respiration, as did the author's case, and the roentgen differential diagnosis from diverticula is scarcely possible. Aneurysms of the heart and aorta offer difficult differential diagnostic problems. Kymographic studies may be helpful. Cardiac aneurysms are usually located anteriorly and inferiorly in the left ventricle and exhibit either no pulsation or a reversed pulsation. Tumors of the heart and

pericardium must also be considered in such cases. Roentgen differentiation of tumor from encapsulated exudate is hardly possible. Exploratory aspiration gave the diagnosis in the author's case. A synopsis of all previously reported cases of pericardial diverticula (51) and encapsulated exudate is given. Diverticula are harmless and have slight practical clinical significance. They are divided into the true form with the wall consisting of both pericardial layers and the "pericardial serosal hernia" which results from increased pressure in the pericardial space produced by cardiac enlargement or pericardial fluid.—*W. A. Evans, Jr.*

Berk, L. H., and Dinnerstein, M. Calcific aortic stenosis. *Arch. Int. Med.*, May, 1938, *61*, 781–797.

Mönckeberg described the pathology of aortic stenosis in 1904. Very seldom has it been recognized clinically. At post mortem, changes are found about the aortic ring, primarily at the roots of the valves. At first, only the outer layer, at the site of the sinus of Valsalva, is affected. From there calcification extends into the leaflets or into the commissures, perhaps with bulging into the sinuses and radiations or circular buckle formations within the valves. The sinuses may be filled with deposits of lime salts. There may be extensions into the ventricles with spur formations beneath the endocardium. These extensions are more common from the posterior aortic valve with extension into the mitral valve. Less frequently, there may be extension into the muscular portions of the septum or even the pars membranacea.

No definite etiology is associated. Only about 20 per cent of the 77 cases reported had a background of rheumatic fever. The authors believe that the condition is primarily degenerative in nature; its occurrence and extent depend on an individual predisposition toward collagen involution and lipoid and calcium deposition.

Most of these cases have been found in middle-aged and elderly subjects. The physical signs include a long, loud, rough systolic murmur transmitted to the vessels of the neck with a systolic thrill over the aortic area (best felt with the patient in the knee-chest position); absence or diminution of the aortic second sound and cardiac hypertrophy. There may be a soft blowing diastolic murmur of aortic insufficiency. A softer systolic murmur may be heard over the mitral area—indicating mitral insufficiency. Of course other physical signs may be associated.

Roentgenoscopy and roentgenography have contributed a great deal to the diagnosis of these cases recently. The authors emphasize the importance of "aimed roentgenography" and the use of a serialograph, using an exposure of 0.05 second with 75 kv. and 100 ma. Fluoroscopically the densities may be seen "dancing up and down"; they cannot be projected outside of the cardiac silhouette and they are not deviated by respiration. They move more rapidly than the pulsating left cardiac border. They are seen in the median line or a little to the right of it in the lowest third of the cardiac area and they are best observed at the right oblique angle. Accommodation of the eyes must be ample and the smallest possible diaphragm must be used. Mitral calcifications are located more medially and show marked rapid pulsatory motion, whereas the aortic deposits of calcium show less extensive and more dancing movement. Occasionally, calcified thrombi may be seen; calcified coronary arteries are rarely recognized. Myocardial calcifications are rare as are also pericardial calcifications. Hilar calcifications can easily be excluded.

Fourteen cases of calcific aortic stenosis observed at Bellevue Hospital during the past seven years are reported. The authors believe that when the physical signs of aortic insufficiency are accompanied with electrocardiographic findings of myocardial damage and when syphilitic disease and acute and subacute bacterial endocarditis are absent, a diagnosis of calcific aortic stenosis is indicated. Roentgenoscopic and roentgenographic examination will confirm or contradict this impression.—*A. A. de Lorimier.*

Parks, Harry. Aneurysm of the innominate artery. *Arch. Int. Med.*, June, 1938, *61*, 898–909.

Interest as to aneurysms has not been very keen during recent years, especially since the development of methods of intensive antisyphilitic treatment. Still, the presence of any aneurysm should be considered before instituting vigorous treatment.

The author reports 3 cases of aneurysm of the innominate. Two of these enlarged suddenly and perforated, the patients dying by rapid exsanguination, after medicinal regimens. The clinical picture of such cases is usually such as

permit definite diagnosis. Intelligent antisyphilitic regimens, of course, are indicated and in the case of aneurysms of the aorta, such therapy would likely be the sole means of treatment but in aneurysms of the innominate, there should be a reasonable surgical approach, and excision of the aneurysm, when small, would seem to be indicated.—*A. A. de Lorimier.*

MISCELLANEOUS

Dessauer, F., Lion, K., and Gökmen, M. Versuche mit der Rotationsbestrahlung. (Experiments with rotation irradiation). *Strahlentherapie*, 1937, *60*, 546–556.

The authors discuss a method of application of the roentgen rays which makes it possible to give large dosages with little or no injury of the skin. The patient's body is rotated so that the dosage of radiation enters through different skin areas. The focus to be irradiated is placed in the axis of rotation so that the total dosage falls upon it though it is administered through different skin areas. The apparatus is described and the details of the technique given. Experiments on the phantom are discussed and then a clinical case described. It was a case of carcinoma of the larynx in a man of fifty. A very large dosage was required. By the use of the rotation method injury of the skin was avoided in spite of the very large dosage used. —*Audrey G. Morgan.*

Davidoff, L. M., Dyke, C. G., Elsberg, C. A., and Tarlov, I. M. The effect of radiation applied directly to the brain and spinal cord. I. Experimental investigations on *Macacus rhesus* monkeys. *Radiology*, October, 1938, *31*, 451–463.

The authors' summary is as follows:

The effects of large single doses of roentgen rays, directly upon the brain and spinal cord of monkeys, were very marked and the rapidity with which the clinical symptoms occurred was proportional to the dosage. A dose of 4,000 r or more to a cerebral hemisphere was followed almost immediately by a more or less well-marked paralysis of the contralateral limbs. After a dosage of approximately 2,000 to 3,000 r, the animals developed a hemiparesis after several months.

None of the animals in which the cerebellum was irradiated, developed any immediate symptoms, but in two of them (dosage 4,000 r and 5,000 r) cerebellar disturbances appeared after from three to five months.

Of the three animals in which the mid-thoracic spinal cord was exposed to the radiation, one developed immediate paraplegia (dosage 5,000 r), and another (dosage 4,000 r) developed a paraplegia after five and one-half months.

These results indicate that the small brain of the *Macacus rhesus* monkey will tolerate massive single doses of x-ray applied directly through the open wound in doses of less than approximately 2,000 r to the cerebrum, and less than 4,000 r to the cerebellum and spinal cord, without causing death of the animal. However, the monkeys that are still alive after about two years, may in the future succumb to the effects of irradiation. It is of particular interest that the disabilities these monkeys presented frequently came on as a late effect following irradiation, and that they were progressive.

In all the animals which died, there were well-marked changes in the central nervous system. When one cerebral hemisphere was irradiated, both the homolateral and the contralateral hemispheres were involved—the latter much less than the former. The changes in the cerebellum following irradiation to this region were similar to those in the cerebrum and lesions were found also in the medulla and cervical spinal cord. When large doses of radiation were applied to the cerebrum, chromatolysis of ganglion cells of the cerebellum occurred; similarly when the cerebellum was thus irradiated, degeneration of ganglion cells of the cerebrum was found. The effects of massive doses of roentgen rays were especially marked in the glia and nerve tissues, and, surprising as it may seem, the changes in the blood vessels were slight in degree. The irradiation produced mainly a parenchymatous degeneration, both nerve and glia cells being profoundly affected, the axis cylinders sometimes appearing to be less severely involved than the myelin sheaths.

The two factors which seemed to play a part in governing the intensity of the histological changes were the dosage of x-ray and, to a less extent, the time interval between irradiation and autopsy. It seemed, both on clinical and histological grounds, that the destructive changes were to some extent progressive, although the period of time during which such progressive changes may occur has not been determined.—*J. H. Harris.*

Sugiura, Kanematsu, and Cohen, Irving. Further study on the direct and indirect actions of radiation on malignant cells. I.—Transplantation of tissue cultures of mouse sarcoma 180 after exposure to roentgen rays: II.—Cultures of tumors irradiated *in vivo*. *Radiology*, Jan., 1939, *32*, 71–76.

This work was undertaken to determine to what extent tissue culture of mouse sarcoma 180 which had been irradiated *in vitro* with a dose of from 100 to 10,000 roentgens will produce tumors when the tissue cultures are implanted in mice.

The growing cultures of sarcoma tissues irradiated with a dose of 1,000 r or less produced typical tumors in every case upon inoculation into mice.

The growing cultures of tumor tissues irradiated with a dose of 2,000 r or over completely failed to produce tumors upon inoculation into animals.

Tumors irradiated *in vivo* with a dose of 1,500 r and left *in situ* for varying length of time before removal and culturing gave outgrowth of tumor cells when the interval in the original host was one, two, three, or four days, but there was no outgrowth of tumor cells when the irradiated tumors were left in the original hosts for five days or longer.—*J. H. Harris.*

Meyer, William H. The Co-relation of physical and clinical data in radiation therapy. *Radiology*, Jan., 1939, *32*, 23–45.

The article is too full of statistical and experimental data to warrant any attempt at abstracting. The author's summary is:

1. That for each type and location of lesion there is a more or less specific quality of radiation best suited for the case at hand.

2. The effort should be made to select that ray quality wherein the maximum absorption will be brought to bear upon the lesion.

3. Excessive penetration obtained by too high voltage and over-penetration results in unnecessary damage to deeper lying tissues, which may have a sensitivity as great or greater than that of the lesion.

4. In small or medium sized parts over-penetration also results in an excessive exit dose, curtailing the efficiency of cross-fire.

5. The present inference is that improvement in depth dosage and effectiveness of radiation is to be sought not alone in a *slower* rate or rhythm of dose administration but also by improved *cross-fire efficiency*.

6. Whereas there may be but little disparity in the physically measured dose and biological radiation efficiency in the more superficially located lesions or even those included well within the first half value layer, our physical experiments and clinical observations indicate that in deep-seated lesions (especially those located beyond the first half value layer) fully *half again as many portals* for cross-fire must be employed than indicated by the present day isodose charts, if the same biological effectiveness is to be obtained as in the more superficially located or intermediate depth lesions.

7. Not until an instrument has been devised which will more reasonably indicate absorption as it occurs in human tissue, will the dosage problem of radiation therapy be more thoroughly understood.—*J. H. Harris.*

Hasché, E., Bolze, J., von Bozóky, L., and von Keiser, D. Beiträge zur Dosismessung an Radiumpackungen. (Measuring of dosage of radium packs.) *Strahlentherapie*, 1937, *60*, 598–614.

The determination of dosage of radium packs by means of dosage tables for radium preparations of different forms and filtration is very unsatisfactory and often impossible. With progress in the photographic industry, a photographic method of determining the dosage of these preparations has been worked out. The method is described in detail and the apparatus illustrated. The radium preparation is laid on plaster and an accurate plaster cast made of it. When the cast is dry, films are laid over it. The time of exposure is measured with a stop watch. For interpreting the films the photometric method is used. Standardizing and measuring films are used. The method of preparing the standardizing films is illustrated. The measuring film determines the greatest intensity (I_{max}) of the preparation to be measured in roentgen hours (r/h) and the half-value line which connects all points with the intensity $I_{max}/2$ with the half-value of I_{max}.

The half-value surface is used as the "field-size" of a radium preparation. It is the surface which is enclosed in the half-value line. The irradiation time (t) necessary for a dose, D, in roentgen units with a given radium preparation can be calculated from the equation

$$t = \frac{D}{0.6\, I_{max}} \text{ hours}$$

in which I_{max} is given in r/h. The I.t law can only be considered valid with a maximum exposure time of half an hour. The time of exposure should not be longer than that. The back-scatter in the patient corresponds about to that of the plaster cast with this method.

The gamma radiation of the standardizing preparation used (radium) and the roentgen radiation of a high voltage apparatus with a voltage of 470 kv. and a half-value layer of 4.6 mm. copper with the same dose of 0.72 r with an Agfa special roentgen film cause the same degree of blackening with an accuracy of about ±20 per cent. This gives a photographic method of testing the roentgen value of the radium irradiation, and the roentgen irradiation of a high voltage apparatus.

To determine the roentgen value of a standardizing preparation the milligram-element equivalent of the preparation to be measured cannot, as a rule, be used in practice. It is necessary to use a punctate measurement of the preparation at the distance which has been used in the standardizing measurement with an absolute measuring apparatus which makes it possible to give the result in roentgens.

The article is illustrated with photographs, tables and graphs.—*Audrey G. Morgan.*

Sweany, Henry C., Klaas, Rosalind and Clark, George L. The detection of crystalline silica in lung tissue by x-ray diffraction analysis. *Radiology*, Sept., 1938, *31*, 299–307.

The method of roentgen-ray diffraction analysis of lung tissue was undertaken by the authors in an effort to distinguish the detrimental types of silica from those varieties causing little if any pathological changes. It has long been known that in certain cases of pneumoconiosis the involvement is a specific fibrosis of the peribronchial lymphatics and the parenchyma of the lung, recognized clinically as silicosis. In other cases there is only an impairment to the lymph drainage, as in anthracosis. The factor which causes the different manifestations of the disease is still obscure, although certain factors play a part as the dampening effect of inert dusts; the time interval following exposure, and the possibility of nontoxic silicates.

Chemical analysis permits only an estimate of total silica and does not differentiate between free and combined silica or between crystalline and amorphous silica.

An analysis of roentgen-ray diffraction was made of lung tissue from a wide variety of cases. The most significant group studied is the one that was termed borderline silicosis, in which were placed the cases that had histories of exposure to small amounts of dangerous dust or to large amounts of questionable injurious dusts. In many of these cases there was also a doubtful gross and microscopic pathology. The amount of silica, as determined by chemical analysis, varied greatly, falling below the amount considered pathological in many and rising to double that level in others. In some of those above the pathological level, no quartz pattern was found. This result suggested that roentgen-ray diffraction analysis affords a selective separation of the harmful silica (quartz) from the relative harmless silicates.

Although the authors make the report as a preliminary one, they feel it has possibilities in the study of borderline cases. The method has certain definite limitations, the principal one to date is that it is applicable only to patients who have died.—*J. H. Harris.*

Jacobson, Lillian E., and Rosenbaum, David. Postmortem findings and radio-activity determinations five years after injection of thorotrast. *Radiology*, Nov., 1938, *31*, 601–607.

A measurement was made of the percentage of gamma-ray activity remaining in the liver of patients who had been given thorotrast intravenously five years previously. At post mortem a marked fibrosis of the liver was found and the microscopic sections showed large masses of a thorium compound to be present. The liver was reduced to ash and upon measurement with a Geiger counter, it was found that the ash of the liver preserved in 10 per cent formalin for six months still retained 27 per cent of the gamma-ray activity of the 75 cc. of thorotrast injected five years previously. The formalin in which the liver was preserved showed no radioactivity.

It was considered likely that the pathological changes found in the liver and spleen were caused by the presence of thorium in these organs for a long period of time and not to antecedent disease.—*J. H. Harris.*

de Abreu, M. Radio-photographie collective. (Roentgen photography of large groups of individuals.) *J. de radiol. et d'électrol.*, May, 1938, *22*, 232–235.

The method employed in chest roentgenog-

raphy of large groups is photography of the fluoroscopic screen. The camera and screen are mounted as one unit on vertical rods so that the assembly can be moved up and down. The factors used were: 50 to 100 ma.; 100 kv.; tube-screen distance 1.2 meters; exposure 2/10 to 2 seconds. A Contax or Leica camera is used; minimum distance from the screen 0.9 meter; Zeiss F 1.5 lens; Agfa Isochrom film F 27 and 28, each photograph being 2.4 by 3.6 cm.

Relative accuracy and inexpensiveness are claimed for the method. Examination in many positions can be made with very little extra expense.—*M. L. Sussman.*

Ghélew, B., and Mengis, O. Mise en évidence de l'intestin grele par une nouvelle technique radiologique. (A new roentgenologic technique for small bowel study.) *Presse méd.*, March 19, 1938, *46*, 444–445.

The patient is prepared with castor oil or epsom salts with, in addition, an irrigation when necessary. The large bowel must be completely empty. A duodenal tube is passed—external diameter 5 mm., internal diameter 3 mm. The end of the tube is clamped off to prevent the entrance of air. With the tube in the duodenum, controlled roentgenologically, 30 gr. of castor oil are introduced into the tube followed by 30 cc. of water; the patient rests for forty-five minutes to an hour until the purge is effective.

One hundred and fifty cubic centimeters of thorium oxide in 100 to 120 cc. of water are passed through the tube and the passage through the small bowel watched roentgenoscopically. Passage is rapid, the opaque material reaching the ileum in fifteen minutes.—*M. L. Sussman.*

Barsony, Th., and Winkler, K. Beiträge zur Röntgenologie der Wirbelsäule; die "elektive" Profil-Röntgenaufnahme der Brustwirbelsäule. (The elective lateral view of the thoracic vertebrae.) *Röntgenpraxis*, Sept., 1937, *9*, 601–608.

When a lateral roentgenogram of the dorsal vertebrae is obtained, the image contains every structure which lies on either side of the vertebral column (ribs, scapulae, lung markings). An ideal lateral view should eliminate the disturbing superimposed shadows. Aside from tomography no other procedure is able to accomplish this goal. However, the ideal can be approached in the living, with the author's suggested technique.

The lateral view is usually obtained with the aid of the Potter-Bucky diaphragm during a respiratory pause, either during deep inspiration or expiration. During inspiration the intercostal spaces become narrower, the diaphragm moves upward and the volume of the lung is smaller. The markings of the compressed lung become more disturbing. In deep inspiration the opposite happens, but the lung markings become so sharp that the evaluation of the structure of the vertebrae is made more difficult.

The author made an attempt to eliminate the disturbing shadows of the lung markings by allowing the patient to breathe during the exposure. Thus the moving lung markings cast no shadows, or only indistinct shadows, which are no longer disturbing.

During respiration the ribs likewise move, mainly the ones on the side away from the film. Exposures obtained during respiration show the ribs on the dependent side to be well delineated, but the opposite ribs are either not visible, or so blurred that they no longer interfere with the bony structure of the vertebrae.

The exposures are necessarily long (10–20 seconds) and the patient is allowed to breathe quietly. The following technique is utilized: 90–100 cm. film-focus distance, 30–50 kv., 40 ma. and Potter-Bucky diaphragm.

Naturally if the paravertebral parts of the lungs contain extensive areas of infiltration or atelectasis (pneumonia, tumor, tuberculosis) the elective lateral view does not improve the results. However, smaller foci of infiltration can be successfully eliminated.

These exposures, obtained during respiration, show a fine structural delineation of the vertebrae, provided the patient is well fixed and the vertebrae are immobile. But even if the vertebrae move slightly, the contours, defects and condensating areas of the bones are still better visible than on the films taken during pause.—*Eugene Freedman.*

Moser, Leonie. Schonende Aufnahmetechnik zur seitlichen Darstellung der unteren Hals- und oberen Brustwirbelsäule. (New technique to visualize the lower cervical and upper dorsal vertebrae.) *Röntgenpraxis*, July, 1937, *9*, 488–490.

Most of the recommended techniques for visualization of the upper dorsal and lower cer-

vical vertebrae of bedridden, injured patients are difficult or occasionally impossible to carry out. If the injured is stout and the neck is short, the usual lateral view will fail to visualize C5, C6 and C7.

Author recommends a new technique for roentgenographic visualization of this region. The patient is in a supine position and the shockproof cone is pushed into the axilla of the abducted arm, the central ray being directed toward the head and slightly anteriorly. The angle of the axis becomes only slightly distorted, is anywhere between 90° and 110°. The casette extends from the upper border of the ear to the head of the humerus. The focus film distance is 50 cm.

With this technique satisfactory lateral views can be obtained on the operating as well as on the extension table. A contrasty film with fine details cannot be expected because there is a wide space between the lower neck and casette.

This method allows, in addition, an evaluation of the trachea in cases of substernal thyroid.—*Eugene Freedman.*

Gambarow, G. Sarcome expérimental après l'irradiation par les rayons roentgen. (Experimental sarcoma after roentgen irradiation.) *J. de radiol. et d'électrol.*, April, 1938, *22*, 177–181.

Experimental radiation malignancy in animals is uncommon. There are only 10 cases reported. The dose necessary is between 1,200 x and 2,000 x; 888 x was insufficient and formed only benign papillomas. A dose of 2,404 x was too much. Ulceration and necrosis were produced but not cancer. In the 2 cases produced by Block, one occurred twenty-three months after 1,450 x (partly without filters and partly with 0.5 mm. Al) and the other with 2,000 x in thirteen months (100 treatments, 0.5 mm. Al). Cancerous ulcer appeared only after nine months of irradiation. In the present case, a rabbit's tibia was irradiated with the following factors: 130 kv., 2.5 ma., 4.0 mm. Al, 23 cm. distance and 25×25 cm. field; 200 r was given at each sitting over a period of eighteen months, treatments being given every six days; 16,000 r was given to the right leg, 12,000 r to the left. Five months after beginning treatment the skin began to brown. There was no definite epilation. There were no general effects. Eleven months after irradiation, there was tenderness over the right side. Treatments were given from September, 1934, to June, 1935, and from September, 1935, to June, 1936. In mid September, 1936, there was no change other than tenderness of the right extremity. Roentgenography on October 4 showed a fracture of the right tibia with marked bone destruction. Death was produced one month later and autopsy revealed changes only in the irradiated areas and in the liver. A fusocellular sarcoma was found on the left side with metastases to the liver and microscopic metastases to the lungs. While other authors have noted that the cancer occurred in an ulceration, the present cases did not ulcerate.—*M. L. Sussman.*